480

SM 112 Portable Dual Trace Oscilloscope

Part 1 Operating Instructions

SM 112

MP MASTER
MA24213

Instruction Manual

OSCILLOSCOPE SM 112

PART 1.

OPERATING INSTRUCTIONS

Issue 2.
(September 1971)

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LIST OF AMENDMENTS

Al.No.	By Whom	Date	Al.No.	By Whom.	Date.

DAMAGE IN TRANSIT

Unpack the equipment and examine it thoroughly to ascertain whether any damage has occurred in transit. Report immediately any such damage to the agent or manufacturer. Retain the four rubberized packing surrounds, should further transit be necessary.

GUARANTEE

All goods manufactured by the Company are guaranteed against defects arising from faulty material or workmanship subject to the goods not having suffered maltreatment or interference. The Company's liability under this guarantee is limited to replacing any part or parts found defective within a period as laid down in Company instructions after the date of delivery or installation.

If goods not of the Company's manufacture are ordered, the guarantee of that company is to be accepted.

LOCAL AGENTS ADDRESS:-

The address of your local agent is:-

DESCRIPTIVE MATTER AND ILLUSTRATIONS.

Descriptive matter, illustrations, dimensions and weights issued by the Company are typical and shall not be held as binding. The Company reserves the right to alter patterns, designs and specifications without notice.

NOTES TO READERS

Circuit Diagram Changes

The circuit diagrams in this manual are provisional drawings only and the reader's attention is drawn to certain minor errors, which will be corrected on the final versions.

1. MAIN FRAME SM 112, CIRCUIT DIAGRAM (SHT.1) POWER SUPPLIES AND CRT CIRCUIT

On the blanking amplifier, label R63 'Brilliance'

2. X-TIMEBASE MODULE SM 602, BLOCK SCHEMATIC

(a) On switch wafers SE-a, SE-b and SE-d, delete reference, A Trigger Source'.
On switch wafers SE-a, SE-b, SE-d and SE-c insert reference 'A Time/cm'.
(b) On switch wafers SH-d, SH-a, SH-b and SH-c delete reference 'B Trigger Source'
On switch wafers SH-d, SH-a, SH-b and SH-c insert reference, 'B Time/cm'.
(c) On switch wafers, SJ-a, SJ-b and SJ-c insert reference 'Sweep Mode Selector'

3. X-TIMEBASE MODULE SM 602, CIRCUIT DIAGRAM (SHT.1) - A Sweep

(a) On switch wafer SE-e, delete reference 'Pull for Auto'.
(b) On switch wafers SE-a, SE-b, SE-c, SE-d, SE-e and SE-f insert reference 'A Time/cm'.
(c) Add reference 'To SJ-e (Sht.2)' to broken line from board Pin 14 (1R96).

4. X-TIMEBASE MODULE SM 602, CIRCUIT DIAGRAM (SHT.2) - B SWEEP

(a) On switch wafers SH-a, SH-b, SH-c and SH-d insert reference 'B Time/cm'.
(b) On switch wafers SJ-a and SJ-b insert reference 'Sweep Mode Selector'.
(c) Add reference 'From pin 14, A-sweep board (SM 602 Sht.1) to unreferenced vertical broken line connected to pin 1 of SJ-a.

5. Y-AMPLIFIER MODULE SM 599, BLOCK SCHEMATIC

(a) CAL indicator ILP1 should read ILP2. ILP2 should read ILP3.

Coding of Sub-Assemblies

To aid the serviceman to trace signal paths from one diagram to another, each PC Board has been allocated a code number. It must be noted that these numbers can only be used in the context of this manual and do not appear on the P.C. Board

MAIN FRAME SM 112	Code ('F' Denotes 'frame)
Power Supply Board and Calibrator Board (card 1)	F1
Power Supply Board (card 2)	F2
EHT Board (card 3)	F3
Blanking Amplifier Board (card 4)	F4
X-output Amplifier Board (card 5)	F5
Y-output Amplifier Board (card 6)	F6

X-Timebase Module SM 602	Code
A-Sweep Board (card 1)	X1
B-Sweep Board (card 2)	X2

Y-AMPLIFIER MODULE SM 599	Code
Y-Amplifier Board (card 1)	Y1
Chopped Blanking Board (card 2)	Y2
Channel 1 Attenuator	Y3
Channel 2 Attenuator	Y4

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SECTION 1

SPECIFICATIONS

1. MAIN FRAME SM 112

Cathode Ray Tube:

Rectangular faced, single-gun P.D.A. Type GEC (M0V) 1474F/G5 or Telefunken D14–131 GH18, P31 phosphor
Display area 10 cm.x 8 cm.
Y-plate sensitivity 5 V/cm (approx.).
X-plate sensitivity 10 V/cm (approx.).
EHT 11 kV.

Z Input Facility:

(i) Input Impedance: 5 kΩ.
(ii) Maximum Input: 10 V.
(iii) D.C. Coupled, d.c. to 15 MHz.

X Input Facility:

(i) Input Impedance: 1 MΩ in parallel with 25 pF (approx.).
(ii) Sensitivity: ≙1 V/cm (gain on x 1) or,
≙0.1 V/cm (gain on x 10).
(iii) Coupling: a.c. or d.c.
(iv) Bandwidth: d.c. to 8 MHz (gain on x 1).
(v) Maximum Input Voltage: 500 V peak.

X Shift:

(i) X gain at x 1 : > 20 cm.
(ii) X gain at x 10 : > 200 cm.
(iii) Fine Shift : 2 cm.

Calibration Facility:

(i) Waveshape: Square wave.
(ii) Frequency: 1 kHz ± 1%.
(iii) Rise Time: < 1 μs.
(iv) Output Levels: 3 mV, 10 mV, 30 mV, 100 mV, 300 mV, 1 V, 3 V, 10 V, 30 V p-p.+30 V d.c.
(v) Accuracy of Output levels: D.C. level set against external standard (i.e., digital voltmeter).
A.C. Signals obtained by attenuator, accuracy ± 1% based on d.c. level.

Spot Locator :

Restricts outputs of the X and Y deflection amplifiers to bring the trace onto the screen, irrespective of gain and shift settings. It also overrides brightness and blanking to display the trace or spot.

Trace Rotate :

Provided to rotate the display to align it with vertical and horizontal lines of graticule.

Power Supply:

(i) Voltage Range: 90 V to 138 V
90V – 110 V
102 V – 124 V Continued overleaf:–

112 V – 138 V

180 V to 276 V

180 V – 220 V

204 V – 248 V

224 V – 276 V

(ii) Frequency: 45 Hz to 440 Hz.

(iii) Power Consumption: 100 W (approx.). Depends upon plug-in module used.

Ambient Temperature Range: 0 °C to +45 °C in a dry atmosphere.

Storage Temperature Range: −10 °C to + 70 °C.

Dimensions:

(i) Height: 305 mm. (12 in.).

(ii) Width: 203 mm. (8 in.).

(iii) Depth: 457 mm. (18 in).

Weight: 13.6 kg. (30 lbs.).

TIMEBASE MODULE SM 602

Sweep Modes

4 – modes as follows:

A only

A marked by B

A delayed by B

Mixed.

A Sweep

(i) Sweep Speeds: 50 ns/cm. to 1 s/cm. in a 1, 2, 5 sequence in 23 calibrated steps.

(ii) Fine Sweep Speed: Continuously variable by 3:1 over the complete sweep range.

(iii) Sweep Magnifier: Sweep speed can be increased to 5 ns/cm by a x 10 switch on the SM 112 Main Frame.

(iv) Sweep Linearity: ± 2% on all calibrated sweep speeds.

(v) Measurement Accuracy: ± 5% over 0 °C to +45 °C.

(vi) Single Shot: Available on all modes of operation including Auto.

(vii) Sweep Calibration: A present control allows the speed to be adjusted.

B Sweep:

(i) Sweep Speeds: 50 ns/cm to 1 s/cm in 23 calibrated steps in a 1, 2, 5, sequence.

(ii) Sweep Magnifier: Sweep speed can be increased to 5 ns/cm. by a x 10 switch on the SM 112 Main Frame.

(iii) Sweep Linearity: ± 2% on all calibrated sweep speeds.

(iv) Measurement Accuracy: ± 5% over 0 °C to +45 °C.

(v) Calibrated Sweep Delay: Delay time range 50 ns to 10 s provided by 10-turn helipot.

A Trigger Facilities

(i) Trigger Source

Internal : Channel 1
Channel 2
Line (a.c. supply source)

External: From signal applied to A TRIG IN connector

External ÷ 10: From signal applied to A TRIG IN connector and attenuated x 10.

(ii) Slope: Sweep can be triggered from positive-going or negative-going slope of trigger waveform.

(iii) Level Control Range:

Internal Trigger: ± 5 cm

External Trigger: ± 5 V

External 10:1 Trigger: ± 50 V

(iv) Trigger Coupling:

	3 dB L.F. Point	3 dB H.F. Point
AC:	10 Hz	> 100 MHz
HF REJ:	0	45 kHz
LF REJ:	15 kHz	> 100 MHz
DC:	0	> 100 MHz

(v) Trigger Sensitivities:

Internal Trigger: 2 mm p-p, External Trigger: 0.2 V } Frequency d.c. to 15 MHz

Internal Trigger : 1.5 cm, External Trigger: 1.5 V } Frequency 100 MHz

(vi) Auto: Provides a timebase automatically in the absence of a trigger signal.

B Trigger Facilities
(Used on 'gated' operation only)

(i) Trigger Source
(ii) Slope
(iii) Level Control
(iv) Trigger Coupling
(v) Trigger Sensitivites

} As for A sweep facilities.

NOTE: When the PULL GATED switch is pushed in, the B trigger controls are inoperative and the B sweep starts at a point controlled by the DELAY helipot.

Ambient Temperature Range: 0 °C to +45 °C in a dry atmosphere.

Storage Temperature Range: −10 °C to +70 °C

Dimensions:

(i) Height: 108 mm (4.5 in)
(ii) Width: 120 mm (4.75 in)
(iii) Depth: 330 mm (13 in)

Weight: 1.36 kg (3 lbs.)

3. Y-AMPLIFIER MODULE SM 599

Vertical Display Modes :	Channel 1 only. Channel 2 only. Dual Trace, alternating between channels at the sweep repetition rate. Dual Trace, chopped between channels at 200 kHz (approx.) Channel 1 + channel 2 (Algebraic add). (Channel 1 – channel 2 can be obtained by inverting CH2)
Bandwidth (each channel):	AC Coupled: 10 Hz to 100 MHz AC Coupled: (sensitivity increased to 1 mV in x 10 position) 10 Hz to 40 MHz. DC Coupled: DC to 100 MHz. DC Coupled: (sensitivity increased to 1 mV in x 10 position) DC to 40 MHz.
Rise Time (each channel) :	(i) 3.5 ns on x1. (ii) 9 ns on x 10.
Sensitivity Range (each channel):	10 mV/cm to 50 V/cm in 12 calibrated steps, increased to 1 mV/cm in x 10 position.
Fine Gain (each channel):	Provides continuously variable deflection sensitivity between calibrated positions of V/cm switch. The control range of 3:1 reduces the deflection sensitivity to a minimum of 150 V/cm, uncalibrated. Calibrated position indicated by a mechanical detent and a lamp.
Maximum Input Voltage (each channel):	500 V d.c. (or d.c. + a.c. peak).
Input Impedance (each channel):	1 MΩ with 23pF in parallel.
Pulse Fidelity (each channel):	Overshoot and ringing < 4% and 6% overall. The internal amplifier is capable of displaying a 6 cm picture at 100 MHz without distortion.
Measurement Accuracy (each channel):	3% over 0 ^{o}C to +45 ^{o}C.
Signal Delay (each channel):	160 ns.
Y-shift (each channel):	Greater than 20 cm of vertical shift is provided.
Input Coupling (each channel):	AC (Capacitive) coupled. DC (Direct) coupled. GND amplifier input grounded. Input signal disconnected from amplifier.
Invert Facility (channel 2 only):	Display on CH1 + CH2 mode becomes CH1 – CH2. Selection indicated by a lamp.

Differential Facility:	Provided by algebraic add and invert. Common mode rejection ratio on 10 mV/cm. range is at least 40 dB with frequencies up to 5 MHz.
Probe Power (each channel):	± 12 V stabilised d.c. (50 mA max.)
Ambient Temperature Range:	0 °C to +45 °C in a dry atmosphere.
Storage Temperature Range:	−10 °C to +70 °C.
Dimensions:	(i) Height: 108 mm. (4.5 in). (ii) Width: 120 mm. (4.75 in). (iii) Depth: 330 mm. (13 in).
Weight:	1.13 kg (2.5 lbs.).

SECTION 2

GENERAL INFORMATION

1. INTRODUCTION

The oscilloscope SM 112 (Fig. 2-1) is a general-purpose, dual-channel, wide-bandwidth instrument. The display is bright and the controls are arranged for ease of operation. Throughout the oscilloscope, silicon transistors and integrated circuits are used to achieve high performance, long-term reliability and low power consumption. Being portable and robust, the oscilloscope is suitable for use in a large range of environmental conditions, and yet it provides the accuracy and versatility required of a laboratory instrument.

2. MAIN FRAME SM 112

2.1 The main frame unit of the oscilloscope contains the power supplies to drive the main frame circuits (including the c.r.t.) and the plug-in modules. It also contains the output amplifiers to drive the horizontal and vertical deflection plates of the c.r.t., an amplifier to provide the 'Z' modulation facility and a switchable calibrator to cover all Y deflection coefficients and to calibrate the timebase module at 1 kHz.

2.2 The cathode ray tube has a rectangular display area of 10 cm x 8 cm and an internal graticule to minimise parallax errors of measurement. A trace rotate control permits the trace to be aligned with the graticule. Horizontal and vertical deflection is obtained electrostatically and the p.d.a. voltage is approximately +11 kV with respect to the cathode. Controls to adjust the focus and brilliance and to minimise astigmatism are provided. The graticule control, which is coupled to the supply switch, can be adjusted to illuminate the graticule. A spot locator control restricts the outputs of the X and Y output amplifiers in the main frame to bring the trace onto the screen, irrespective of other control settings. A contrast control is provided which is used to adjust the relative brilliance between the 'A' and 'B' sweeps when the delayed sweep mode is being used.

2.3 20 cm of horizontal movement is provided by the coarse X shift control; the fine X shift control provides approximately 2 cm. Coupled with the fine shift control is a x10 control to increase the sweep rate by a factor of 10. An X input selector allows the horizontal deflection to be derived from either an external source (a.c. or d.c.) or internally from the timebase module. An X input connector is provided on the front panel.

2.4 A calibrator provides a 1 kHz squarewave output of switched amplitudes from 3 mV to 30 V peak-to-peak in a 1, 3, 10 sequence. An additional +30 V d.c. output can also be switched-in so that the calibrator output can be checked using a digital voltmeter. The $\pm$ 1% voltage and frequency limits are valid over the temperature range – 10 ^{o}C to +45 ^{o}C.

2.5 The oscilloscope can be operated from an a.c. supply in the ranges 180 V to 296 V or 90 V to 138 V. These two ranges are sub-divided into 3 groups: 90 V – 110 V, 102 V – 124 V, 112 V – 138 V: 180 V – 220 V, 204 V – 248 V, 224 V – 276 V, frequency 45 Hz – 440 Hz. Power consumption is approximately 120 VA.

2.6 The d.c. supplies are generated by a transformer, and a rectifier and stabiliser board. The c.r.t. supplies are produced by a d.c./d.c. converter.

3 TIMEBASE MODULE SM 602

3.1 Timebase Module SM 602 is used to generate both normal and delayed calibrated sweeps from 1 s/cm to 50 ns/cm

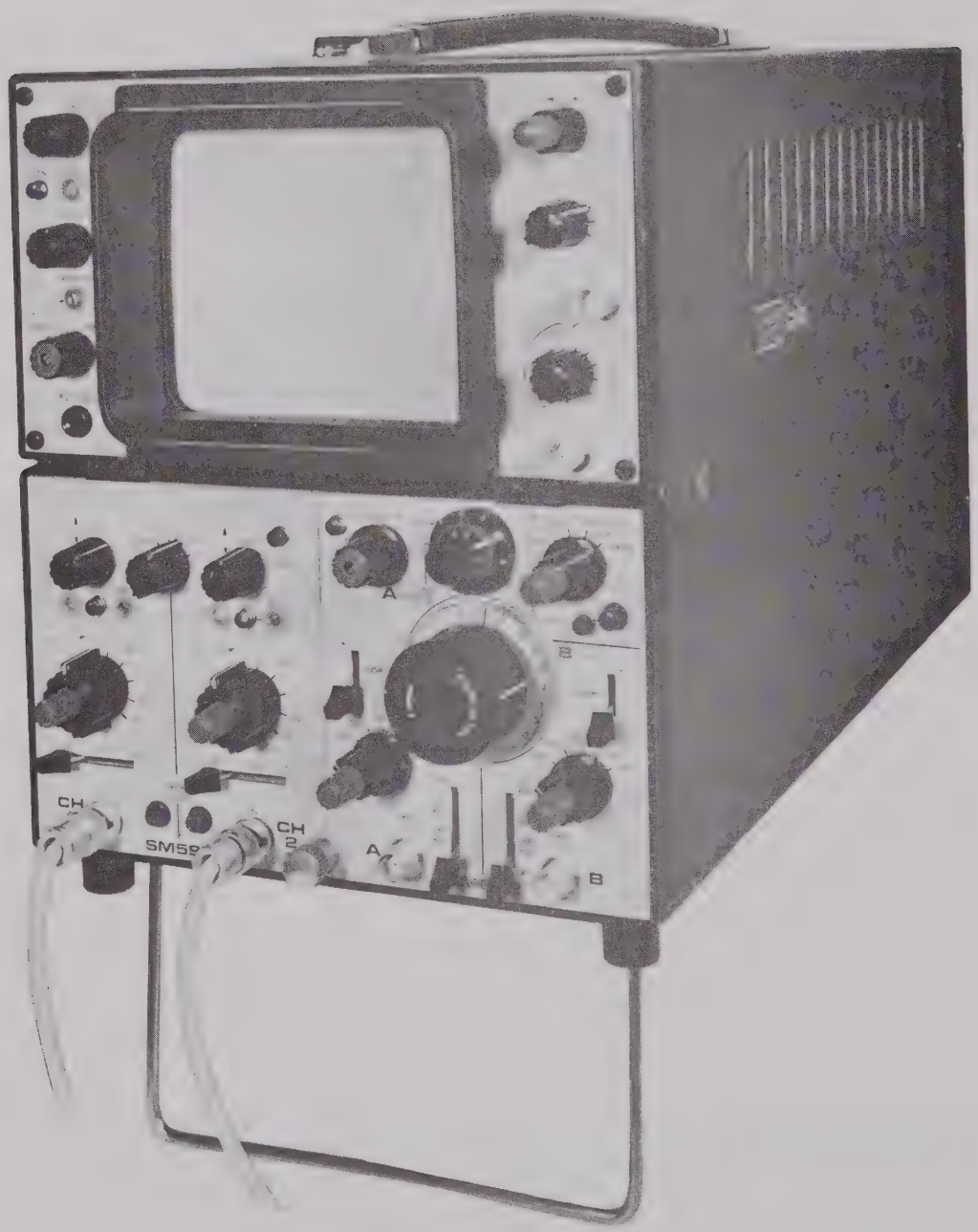


FIG. 2-1. OSCILLOSCOPE SM 112 WITH PLUG-IN MODULES

(increased to 5 ns/cm when x 10 facility is used.) Lock-on triggering up to greater than 100 MHz and the synchronising of complex waveforms is made possible by operation of a variable hold-off control (HF Sync).

3.2 Stable triggering is provided over the full range of the selected trigger waveform. The trigger source can be internal from either channel, internal from the supply frequency, external or external ÷ 10. The internal channel 1 or channel 2 trigger is derived from the appropriate preamplifier via a separate amplifier; the external trigger, if of large amplitude, can be attenuated by a factor of 10 so that the trigger controls can operate over the whole of the waveform amplitude. Automatic triggering can be selected which provides a timebase line in the absence of a signal, which locks onto the input waveform when a vertical signal is applied.

3.3 The trigger is derived from an amplified and squared portion of the selected trigger signal, this portion being determined by the slope and level controls. The edge of the signal then initiates the sweep. A transistorised Schmitt trigger circuit is used to amplify and square the trigger input. The circuit is 'held off' after each trigger transient so that the output is always at a frequency below approximately 5 MHz. Above 5 MHz, the circuit divides and locks onto a sub-multiple of the input frequency.

3.4 A.C. LF reject, H.F. reject or d.c. trigger coupling can be selected: an additional mode, auto, causes the amplifier to generate a trigger at a slow rate. In the absence of a trigger input, the trigger rate is dependent only on the timebase range in use. The trigger coupling, trigger and slope switches are duplicated on the A and B sweeps.

3.5 A gated trigger mode is also provided for the delayed (B) sweep with selection of either internal or external as the source of the gating pulse. This allows the A sweep to be triggered from channel 1 trigger input, while the B sweep is gated by signals on channel 2 trigger input.

3.6 The horizontal deflection system has 23 calibrated sweep rates from 50 ns/cm to 1 s/cm in a 1, 2, 5 sequence. Normal A continuously variable control of sweep rate covers the switched ranges, the calibrated position being indicated by a mechanical detent and a lamp.

3.7 A timebase sweep is initiated when a bistable, formed by integrated logic elements, is set by a trigger signal. A bootstrap generator is gated by the bistable and when the output of this generator reaches a defined level, the bistable is reset and held off to allow the bootstrap to recover. The hold-off time and sweep rate are both controlled by the range switch. However, the hold-off time can be varied by a small amount (HF SYNC) whenever difficulty is experienced in triggering from a high-frequency signal.

3.8 A single-shot facility is available on all modes of operation, including auto. The push-button when operated primes the A sweep, which is triggered from the first selected trigger signal. The A MARKED BY B or B DELAYED BY A modes can also be selected, if required.

4. Y-AMPLIFIER MODULE SM 599

4.1 The Y-Amplifier Module SM 599 is a dual-trace vertical amplifier system obtaining its power supplies from the SM 112 Main Frame. The vertical deflection system has a bandwidth of d.c. to better than 100 MHz, and 12 calibrated sensitivities from 10 mV/cm to 50 V/cm can be selected: these sensitivities can be increased by a factor of 10 but with a decrease in bandwidth. The two Y channels are very similar and dual-channel operation is obtained by electronically switching the trace on alternate sweeps of the timebase (alternate mode) or independently of the timebase at approximately 200 kHz (chopped mode). Other modes are channel 1 only, channel 2 only, and channels 1 + 2. The signal on channel 2 can be inverted when required: this facility is especially useful for differential operation (CH1-2).

4.2 Normal shift and fine gain controls are provided in each channel: the Y shift available is greater than 20 cm. and the fine, continuously variable control of deflection sensitivity covers the switched ranges. On each channel, a.c. or d.c. coupling of the signal input can be selected as required. A further position of the input coupling switch, connects the input of the channel to ground, the input signal being open-circuited; this provides a ground reference level without having to physically disconnect the signal input.

4.3 Each channel consists of a step attenuator that provides the 12 calibrated sensitivities, and a preamplifier of high input impedance. The shift control, the fine continuously-variable gain control, and the coarse gain (x1: x10) control form part of the pre-amplifier.

4.4 The outputs of the two preamplifiers are fed to combining and selecting gates which are controlled by the vertical mode selection circuits. The combined deflection signal is fed via a delay line to an output amplifier in the main frame and thence to the Y plates. The delay line introduces a 160 ns delay to enable the leading edge of the pulse, from which the sweep trigger is derived to be displayed,when internal trigger mode is selected. The delay line is mounted in the main frame SM.112

SECTION 3

INSTALLATION

1. INTRODUCTION

1.1 The information contained in this section is intended to assist the operator in the preparation of the instrument for operation.

2. EQUIPMENT LIST

2.1 The oscilloscope is supplied with the following items:

(a) Main Frame SM 112

(b) Y-Amplifier Modules SM 599 and/or SM 554

(c) Timebase Module SM 602

(d) Power lead

(e) Instruction Manual

3. OPTIONAL ACCESSORIES

3.1 Optional Accessories include:—

(a) 10 : 1 Passive Probe, type SMA 10 (cale length 1 metre) and type SMA 11 (cable length 2 metres).

(b) 1:1 Active Probe (100 MHz bandwidth) with 10 : 1 and 100 : 1 attenuators and a blocking capacitor, type SMA 12.

(c) Super 7 Recording Camera

(d) Rubber Viewing Hood SM 11H

(e) Waterproof Carrying Case

(f) Trolley

4. STORAGE PRECAUTIONS

4.1 If the instrument is to be stored for a prolonged period, provide protection against the effects of possible dampness by placing linen bags of silica gel crystals inside the instrument. These should be removed every three months and re-activated by heating in an oven for one hour at approcimately 200 ^{o}C.

5. POWER (MAINS) SUPPLY SELECTION

5.1 The oscilloscope can be operated over the ranges 90V to 138 V, and 180 V to 276 V, 45 Hz to 440 Hz.To convert the

instrument for the local supply:—

(a) Ensure that the oscilloscope is unplugged from the power source.

(b) Select the 90 — 138 or 180 — 276 range as appropriate (see fig 4.2 in Section 4).

(c) Select one of the three 'fine' ranges to cover the exact value of the local power voltage.

(d) Check that the supply fuse FS 1 is at the correct rating (90 V to 138 V — 2A, 180 V to 276 V — 1A, both antisurge.)

6. PLUG-IN MODULES

6.1 Ensure that the plug-in modules are firmly secured in place. If it is desired to replace a module with a different type, proceed as follows:—

(a) Unscrew the single retaining screw located at bottom centre, between the module front panels. Both modules are withdrawn as a combined unit.

(b) The modules are held in together by two ¼-turn fasteners fitted into their internal dividing screens. These are reached by inserting a long-shanked screwdriver through the side of the Y-Amplifier module.

SECTION 4

OPERATION

1. INTRODUCTION

In order that the SM 112 may be effectively used, the operation and capabilities of the instrument must be known. This section outlines familiarisation and general operating information, provides some basic applications to which the oscilloscope may be put, and details the operation of the front and rear-panel controls.

2. SUMMARY OF CONTROLS

2.1 SM 112 Main Frame Controls (Front Panel)

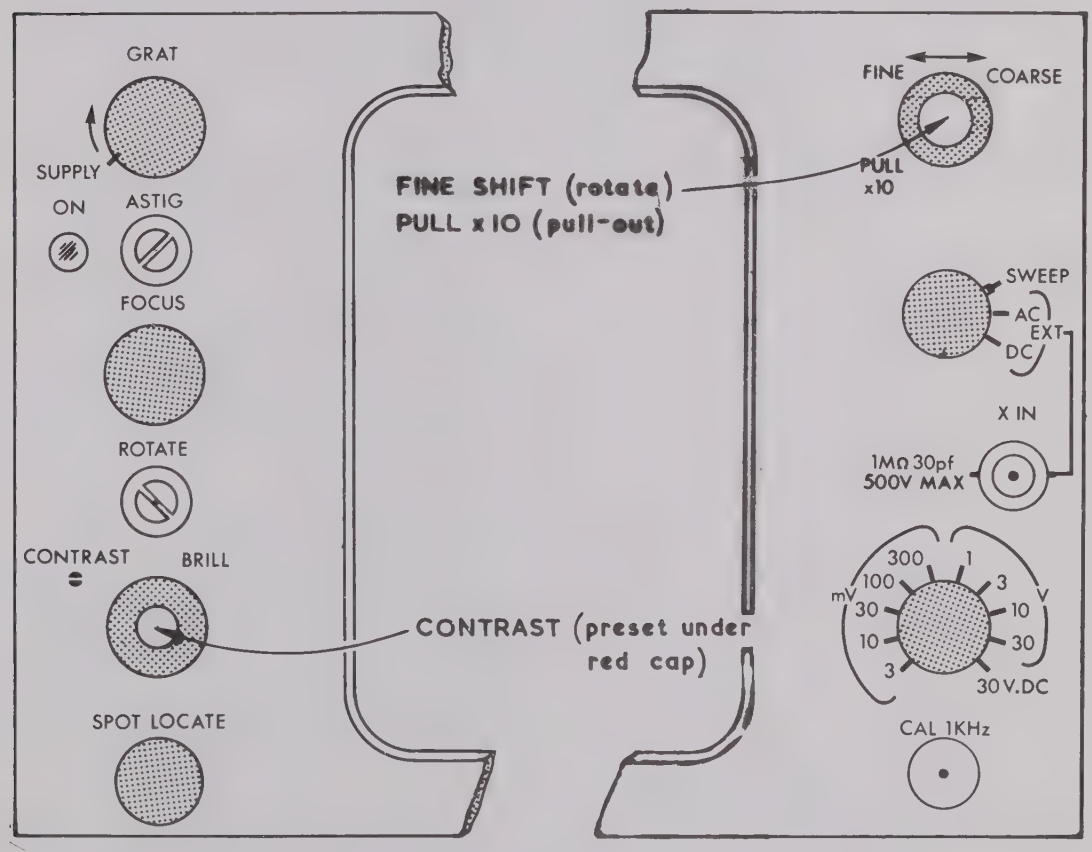


FIG. 4.1. MAIN FRAME (FRONT PANEL) CONTROLS

SUPPLY: GRAT

This controls the power to the instrument. Clockwise rotation switches-on the instrument.
Further clockwise rotation illuminates c.r.t. graticule. AT ON, the SUPPLY ON lamp is lit.

ASTIG and FOCUS

These are used with each other to obtain optimum definition of display. The preset ASTIG control is factory set and should not normally require adjustment.

ROTATE

A preset control, which 'rotates' the display so as to align it with the graticule lines.

BRILL

Controls brightness of display

CONTRAST

A preset control, concentric within BRILL knob. Used to dim the A sweep, when the 'A MARKED BY B' sweep mode is selected.

SPOT LOCATE

When pressed, over-rides the X and Y deflection and brightness to bring the display onto the screen in all modes.

FINE COARSE

COARSE X shift control provides 20 cm of movement (approx.) horizontally across the screen. FINE X shift control (red) knob, when rotated, provides 2 cm of movement.

PULL X 10

Coupled to FINE shift (red) knob (above). When pulled-out is set to x 10 position and increases the X – gain by a factor of 10 In the SWEEP mode, the sweep rate is increased ten times.

SWEEP: AC EXT: DC EXT

This is the X input selector and controls the input to the 'output X amplifier' in the main frame:–

(i) SWEEP: Horizontal deflection provided by internally generated timebase.

(ii) AC EXT: Horizontal deflection provided by an externally derived input applied to the X IN socket, capacitive – coupled (low frequency limit) 3 Hz approx. (–3 dB point).

(iii) DC EXT: Horizontal deflection provided by an externally derived input applied to X IN socket. All components of the sweep waveform are fed to the 'output X – amplifier.'

X IN

A BNC input connection for the external horizontal input for X – axis deflection in the X-Y mode of operation.

CAL 1 kHz (selector and socket)

(i) Selector: 10-position selector to provide 1 kHz calibration signal from 3 mV to 30 V peak to peak, square-wave output in a 1, 3, 10, sequence. A + 30 V d.c. output is also provided so that the output can be checked on a digital voltmeter.

(ii) Socket: Connections are made to external equipment. Square wave output at 1 kHz (or d.c. as above) into a high impedance load. Amplitudes as set by associated selector.

2.2 SM 112 Main Frame Controls (Rear Panel)

Z IN

For connection of external signal when Z modulation facility is required. Signal amplitude 3V – 10 V Max. at 5 kΩ.

SUPPLY VOLTS

Voltage selector to be set to the value of power source. Initially either 90 – 138 or 180 to 276 'coarse' range is selected. Then any one of three 'fine' ranges can be set for each coarse range.

FUSE FS1

Power fuse (antisurge) rated:–

(i) 90 V – 138 V :– 2A.

(ii) 180 V – 276 V : –1A.

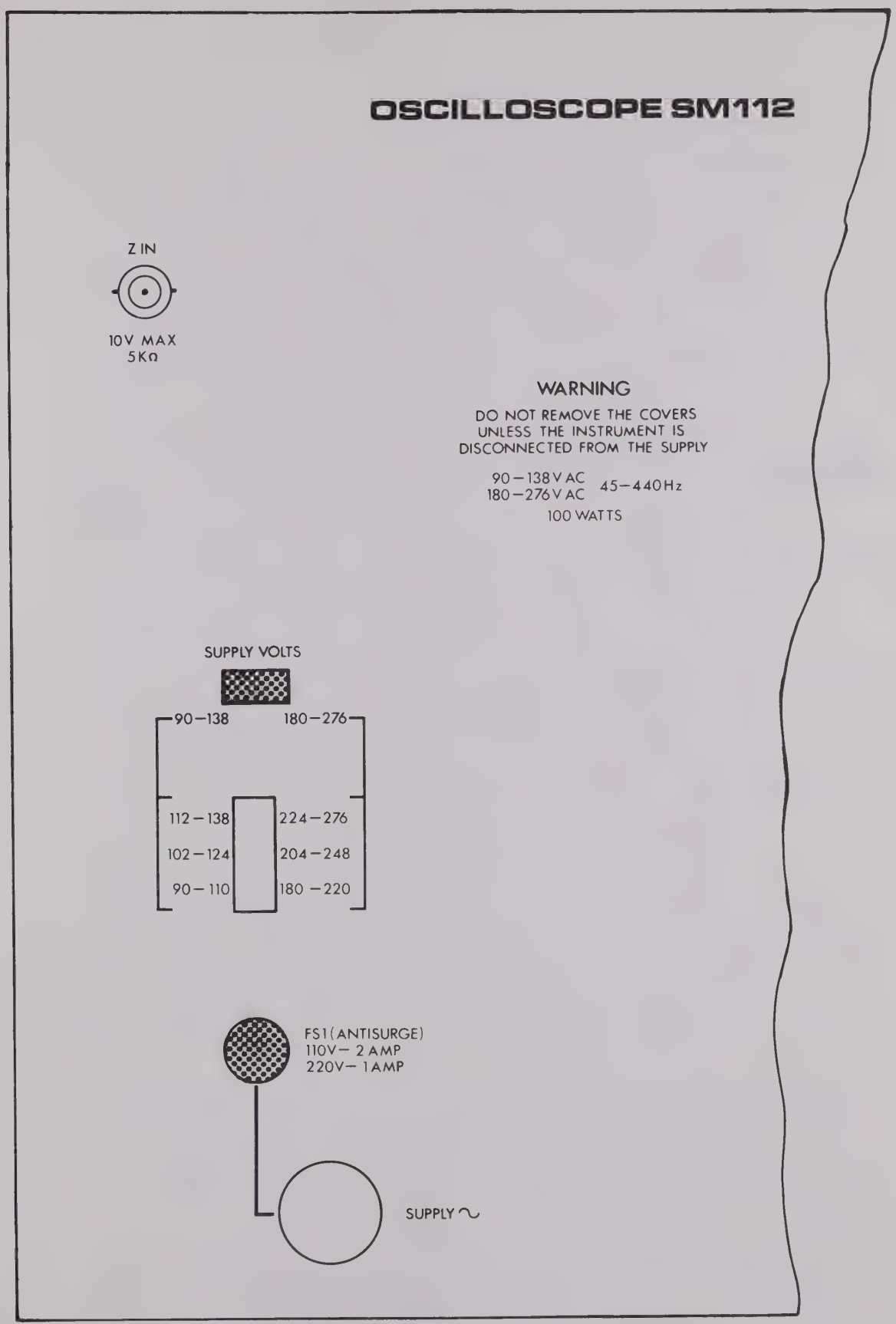


FIG. 4-2. MAIN FRAME (REAR PANEL) CONTROLS

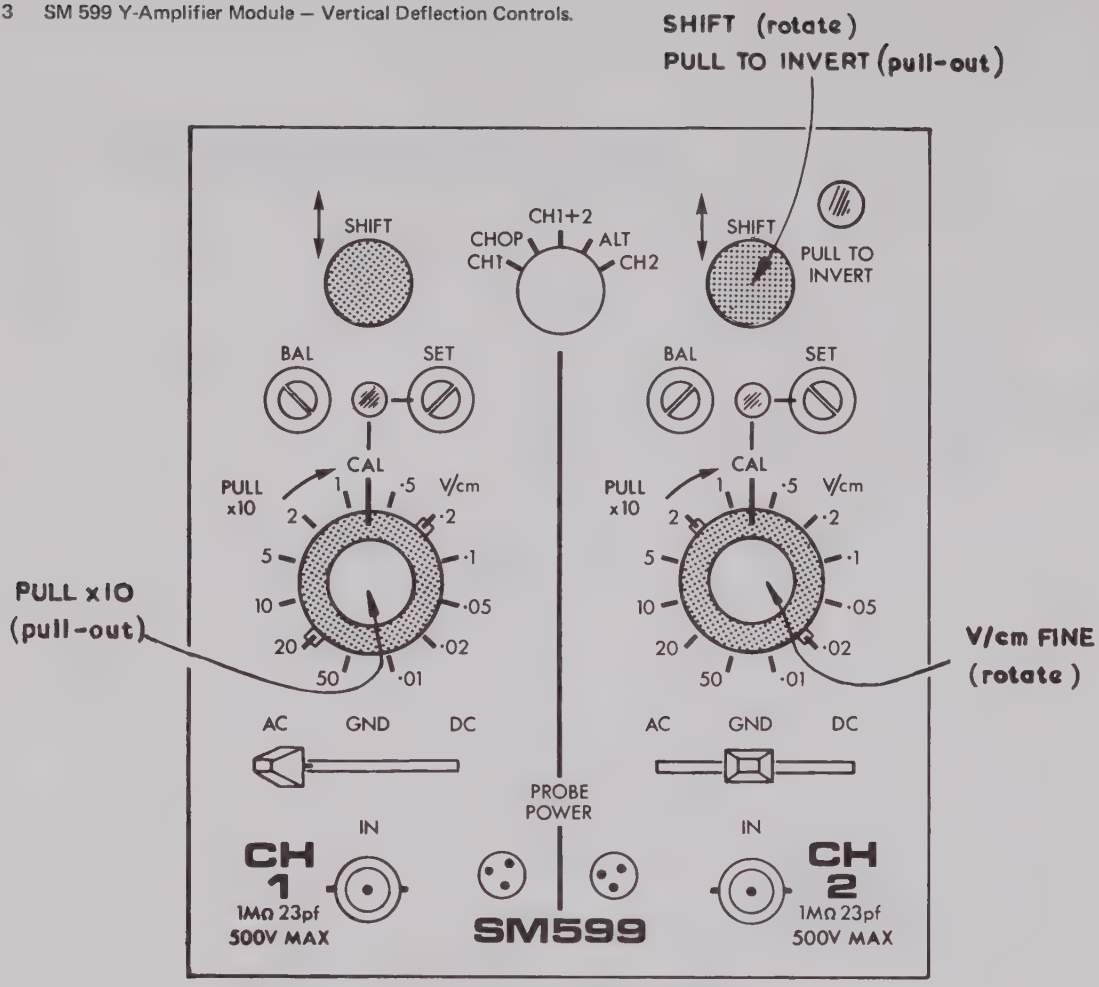


FIG. 4.3. VERTICAL DEFLECTION CONTROLS

Vertical Mode Selector

Selects vertical mode of operation:

CH1: CH1 IN signal displayed.

CH2: CH2 IN signal displayed.

ALT: Dual-trace display of CH1 and CH2 signals. Channel switching occurs at the selected sweep frequency.

CHOP: Dual-trace display of CH1 IN and CH2 IN signals. Channel switching at approximately 200 kHz.

CH1 +2: Signals from both inputs added together.

PULL TO INVERT (CH2 only).

The channel 2 shift control is pulled outwards to obtain PULL TO INVERT, the display on CH1 + 2 mode becomes CH1−2.

PULL X10
(both channels)

The X10 position is obtained by pulling out the 'red' V/cm knob. When set to X10 position, increases the sensitivity of the pre-amplifier by a factor of 10 (V/cm FINE must be in the CAL position for X10 indicated deflection sensitivity).

SHIFT
(both channels)

Controls vertical position of trace.

Input coupling
(AC GND DC)
(both channels)

Controls input signal coupling— **Continued next page:—**

AC: Capacitive coupled (low-frequency limit approx. 10 Hz) (−3 dB point).

GND: Input circuit grounded (input signal disconnected).

DC: All components of input signal connected.

CH1 IN: Input connection for Channel 1 vertical deflection signals, or Y-axis deflection in the X-Y mode of operation.

CH2 IN: Input connection for Channel 2 vertical deflection signals, or Y-axis deflection in the X-Y mode of operation.

V/CM (both channels): Selects the vertical deflection sensitivity in a 1, 2, 5 sequence (V/cm FINE must be in the CAL position for the 'indicated' deflection sensitivity).

V/CM FINE (both channels): Red control, concentric with the V/cm control above it, provides continuously-variable deflection sensitivity between the calibrated settings of the V/cm switch.

BAL (both channels): A preset control which is set so that when PULL X 10 is selected, no Y-shift occurs.

SET (cal) - both channels: A preset control to set the Y-channel calibration.

PROBE POWER (both channels): Provided for connection of an active probe and each connector provides ± 12 V d.c. (at 50 mA.)

2.4 SM 602 Timebase Module — Horizontal Deflection and Trigger Controls.

Sweep Mode Selector: Four-position mode selector, positions as follows:—

(i) A ONLY: 'A' sweep selected for display. 'B' sweep not used.

(ii) A MARKED BY B: The 'B' sweep is used to identify a portion of the A sweep.

(iii) B DELAYED BY A: The 'B' sweep is displayed, delayed by the time as set by the A TIME/cm switch, coupled with the DELAY helipot.

(iv) MIXED: Used to view expanded and unexpanded portions of the same wave form.

A TIME/cm and B TIME/cm: Concentric rotary switches used to select the horizontal sweep rate of the A and B sweeps in a 1, 2, 5 sequence (TIME/cm VAR must be rotated to the CAL position for the 'indicated' sweep rate). Normally set for A sweep, selected rate bracketed by twin black lines. B sweep is selected by rotating the knob.

TIME/cm VAR and CAL: TIME/cm VAR provides continuously variable A sweep rate between settings of the A TIME/cm switch. When set to CAL, the CAL lamp is lit.

SET (cal):

Preset control, concentric within TIME/cm VAR knob. Used to set the sweep calibration.

DELAY:

A 'helipot' control. 10-turn calibrated dial with a resolution of 0.1% (1000 divisions).

CAL Lamp:

Lights-up when TIME/cm VAR control is set to cal position.

A TRIG SOURCE:

Selects source of triggering signal from horizontal sweep:

CH1: Sweep triggered from signal applied to CH1 IN.

CH2: Sweep triggered from signal applied to CH2 IN.

EXT: Sweep triggered from signal applied to A TRIG IN

EXT÷10: External trigger at TRIG IN attenuated by a factor of 10.

LINE: Sweep triggered by internal power (mains) source.

A SLOPE + – :

Selects slope of trigger signal that initiates the sweep:

+: Sweep triggered from positive-going edge of trigger signal.

–: Sweep triggered from negative-going edge of trigger signal.

A LEVEL:

Permits the sweep to be initiated on the selected portion of the trigger signal.

HF SYNC (A sweep only):

Concentric within sweep mode selector and permits stable triggering to be obtained at high sweep repetition rates (greater than 5 MHz). Has negligible effect at lower repetition rates.

A Trigger Coupling

Four-position slider switch with positions as follows:–

AC: This position is used when triggering from signals in the range 10 Hz to greater than 100 MHz is required.

LF REJ: At this position, signals below 15 kHz are attenuated. Operable up to greater than 100 MHz.

HF REJ: At this position, signals above 45 kHz are attenuated. Used to trigger from signals with a high frequency noise co

DC: Used when triggering from very low frequency components below 10 Hz.

AUTO (A sweep only):

This is coupled to the A LEVEL control and is pulled-out to select AUTO. When selected, automatic triggering at a slow rate occurs, governed by the sweep rate selected. With AUTO de-selected (pushed-in) the timebase appears ***only*** when a trigger signal is selected.

A TRIG IN:

An input socket for external trigger signals for the A sweep.

SINGLE SHOT/RESET button and lamp:

Can be used on all modes of operation including AUTO. When pressed, the button 'primes' the A sweep , which then fires

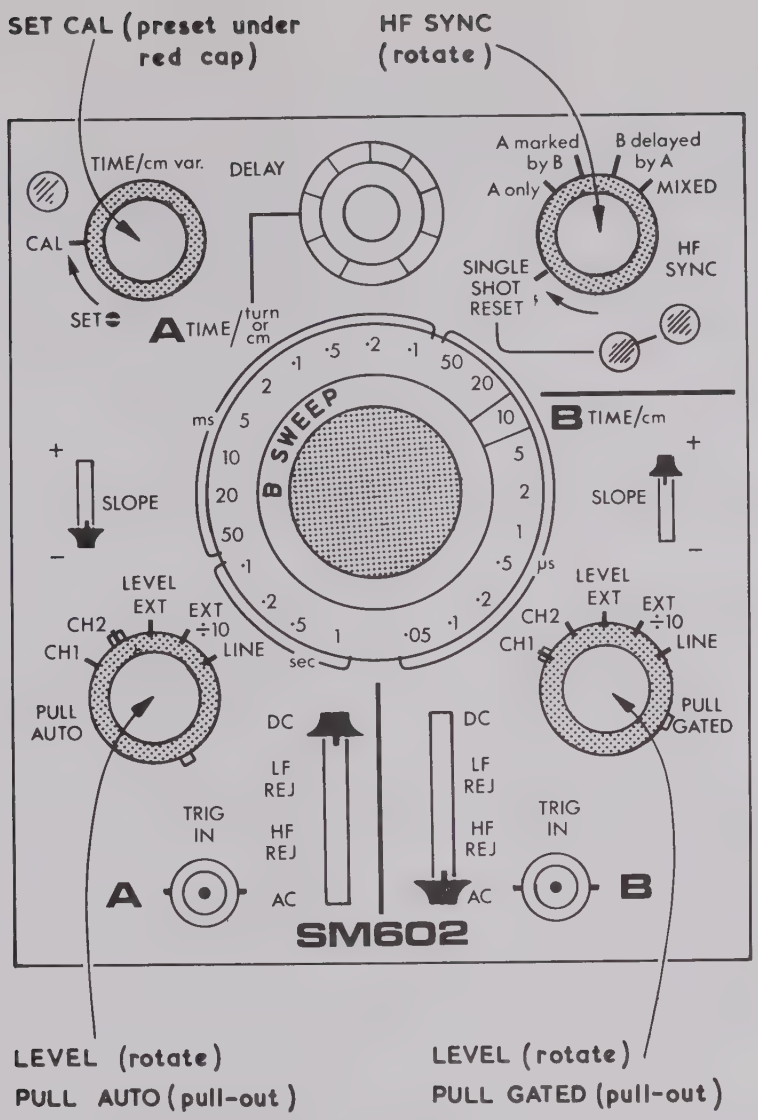


FIG. 4.4. HORIZONTAL DEFLECTION AND TRIGGER CONTROLS

SINGLE SHOT/RESET (cont.)

on the first selected trigger signal. The 'B' sweep operates from the A sweep as normal. The lamp lights-up when the 'A' sweep generator has been primed and is ready to produce a sweep. The lamp goes out at the end of the next sweep.

B TRIG SOURCE
B SLOPE + –
B LEVEL
B Trigger Coupling

These controls are used in the same way as those for 'A' sweep, but only in the 'gated' mode (see PULL GATED control).

PULL GATED:

Coupled to the (red) 'B' sweep LEVEL control. GATED mode is obtained by pulling out the 'red' knob. In this mode, the 'B' sweep is triggered by the next selected 'B' pulse after the delay time as set by the DELAY helipot.

3. FAMILIARISATION

3.1 Graticule

3.1.1. The graticule is internally marked on the c.r.t. to enable accurate, parallax free measurements to be made. It is marked with eight vertical and ten horizontal divisions. Each division is 1 cm square, each major division being divided into five minor divisions at the centre vertical and horizontal graticule lines. The horizontal and vertical deflection systems are calibrated to the graticule for accuracy of measurement. Two additional horizontal 'dotted' lines are positioned at 3.2 cm above and below the centre horizontal line. These are used to facilitate rise time measurement.

3.2 Controls

3.2.1. It is recommended that the procedure detailed in (a) to (m) be followed completely for a first-time familiarisation with this instrument. It is assumed that the appropriate line voltage settings have been made as in ***Section 3, Installation.***

(a) Set the front-panel controls as follows:—

(i) Main Frame Controls (SM 112).

BRILL	Counter-clockwise
FOCUS	Mid-position
ASTIG and ROTATE	Leave untouched
X SHIFT (COARSE)	Mid-position
PULL x10	Pushed-in
CAL 1 KHz	Set to 1 V position
X INPUT SELECTOR	Set to SWEEP

(ii) Vertical Deflection System Controls (SM 599) (both channels if applicable).

V/CM	0.2 V/cm
SHIFT	Mid-position
V/CM FINE	CAL
PULL x10	x1 (Pushed-in)
INPUT COUPLING	DC
MODE	ALT
PULL TO INVERT	Pushed-in

(iii) Horizontal Deflection and Trigger Controls (SM 602)

SWEEP MODE SELECTOR	A ONLY position
TIME/cm	0.5 ms
TIME/cm VAR	CAL
A TRIG SOURCE	CH1
A LEVEL	Mid-position
A SLOPE	+
AUTO	Pull to select
HF SYNC	Mid-position

(b) Connect the SM 112 to a power supply that meets the voltage and frequency requirements of the instrument

(c) Set the SUPPLY switch on. Check that the SUPPLY ON panel lamp and ***all three*** CAL lamps light. Allow several minutes to elapse so that the instrument can reach its operating temperature before proceeding to (d).

(d) Connect the 1 V, 1 kHz calibration output to CH1 IN.

(e) Advance the BRILL control until the intensity of the trace is adequate. Slight adjustment of the CH1 and CH2 SHIFT controls may be required to position the traces on the screen.

NOTE: To increase the life of the c.r.t. do not turn the BRILL control higher than necessary for a satisfactory display.

(f) Adjust the FOCUS control to obtain a well-defined trace. The ASTIG control is preset and should not require adjustment.

NOTE: To check for proper setting of the ASTIG control, slowly turn the FOCUS control through the optimum setting. If the ASTIG adjustment is correctly set, the horizontal and vertical portions of the CH1 trace will come into sharpest focus at one position of the focus control. The setting of the ASTIG control should then be correct for any display.

(g) Adjust the CH2 SHIFT control to position the CH2 trace coincident with the centre horizontal graticule line. If the trace is not parallel adjust ROTATE until it is aligned. Offset the CH2 trace from the c.r.t. screen.

(h) Note that the vertical deflection (CH1) of the displayed calibration waveform is exactly five (1 V, i.e. 5 cm x 0.2 V/cm). If not adjust SET (Cal) preset control on CH1.

(j) Note that the period of the displayed waveform is exactly 2 cm (1 ms, i.e. 2 cm c 0.5 ms/cm). If not, adjust the preset SET (cal) control concentric with TIME /cm VAR control.

(k) Pull the x10 control on the main frame. The sweep rate should be increased by a factor of 10. Return the knob to the x1 position.

(m) Set the trigger SLOPE switch to —. Note that the trace starts on the negative-going portion of the square wave. Return the switch to + : note that the trace now starts on the positive-going portion of the square wave.

3.2.2. This completes the basic familiarisation procedure. Detailed information is given under ***General Operating Information.***

4. GENERAL OPERATING INFORMATION

4.1 INTRODUCTION

4.1.1. Figure 4-5 shows a block diagram of the instrument illustrating the main functional units and user controls. An appreciation of the location of these controls in relation to the various functional units is especially helpful if full use of the instrument and its applications is to be made. Cross-reference to the block diagram and to the description of the function of the front-panel controls is recommended, therefore, whenever reference is made to the ***General Operating Information*** and ***Basic Application*** sections.

4.1.2. To increase c.r.t. life, avoid advancing the BRILL control beyond a setting that provides a satisfactory display. In

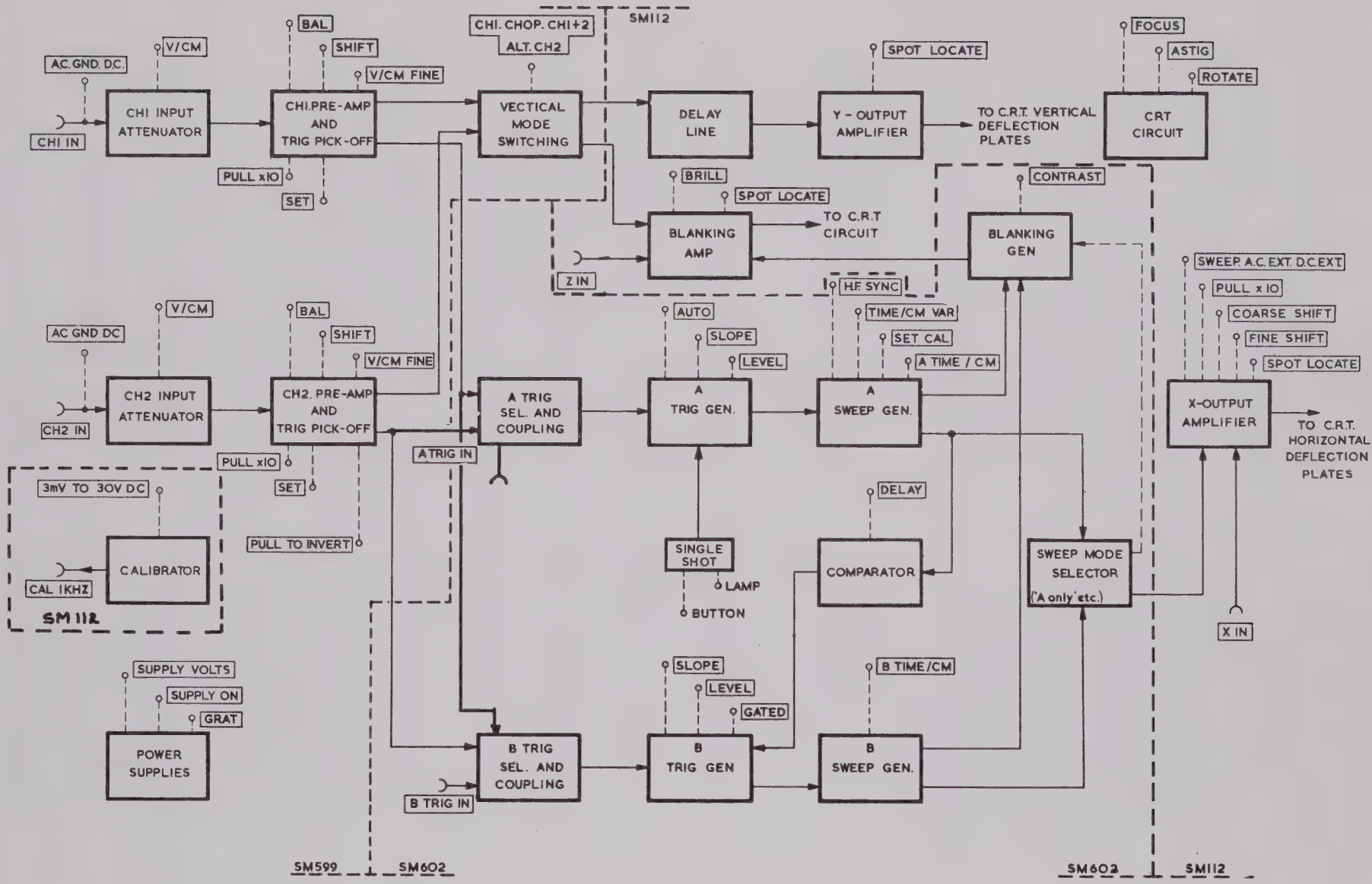


FIG. 4-5. BLOCK SCHEMATIC OF MAIN FUNCTIONAL UNITS AND USER CONTROLS

addition, ensure that the BRILL control is not set too high when the TIME/cm switch is changed from a fast to a slow sweep rate.

4.1.3 The focus of the display may be affected when the BRILL control is adjusted. Slight readjustment of the FOCUS control may thus be required whenever the brilliance level is changed

4.2 TRIGGER FACILITIES (SM 602)

4.2.1. Trigger Source

(a) ***CH1 and CH2.*** The timebase can be triggered from the signal input for most applications. In the CH1 and CH2 positions of the TRIG SOURCE switch, the trigger signal is derived from the signal applied to the relevant channel of the vertical deflection system. For dual-trace operations, special triggering conditions may be required.

(b) ***EXT and EXT÷10.*** The timebase can be triggered from an external input connected to TRIG IN, the TRIG SOURCE switch being set to either of these positions. However, for a stable display, the trigger signal must be time-related to the displayed signal. Typical uses of the external trigger facility are when the internal trigger is too low in amplitude for stable triggering, when the internal trigger contains components on which triggering is not desirable, or when time relationships with respect to a certain time have to be examined. In the latter case, a typical external trigger waveform could be a pre-pulse or clock pulse. High amplitude trigger signals can be attenuated by 10:1 (EXT ÷10 position) to broaden the range of the LEVEL control.

(c) ***LINE.*** In this position of the A or B TRIG SOURCE switch, a portion of the supply line voltage is used as an internal trigger. Typical uses of this facility are when the displayed signal is related in time (multiple or sub-multiple) to the line frequency, or when a stable display of a line-frequency component in a complex waveform is required.

4.2.2. Trigger Coupling Selector.

(a) ***AC.*** Used in most applications, unless triggering from a very low-frequency component is required (below 10 Hz).

(b) ***HF REF.*** This position is selected when it is required to trigger from 'noisy' signals. High-frequency components above 45 kHz are attenuated.

(c) ***LF REJ.*** At this position low-frequency signals, below 15 kHz are attenuated.

(d) ***DC.*** This position is selected where triggering from a very low frequency (below 10 Hz) is required.

4.2.3. AUTO Selection

(a) This affects the A sweep only. When selected (pulled out) the associated LEVEL control is still operative. In the absence of a trigger, the timebase free-runs at a rate dependent upon the selected sweep rate.

4.2.4. GATED Selection

(a) This can be selected on the B sweep only. This mode is selected to remove 'jitter' from unstable input waveforms. The B sweep is triggered by the next selected B pulse after the delay time as set in by the DELAY helipot.

4.2.5. Sweep Rate Selection

4.2.5.1. The A TIME/cm and B TIME/cm switches select the calibrated sweep rates for the A and B sweep generators. The TIME/cm VAR control provides continuously variable sweep rates between the settings of the A TIME/cm switch. Whenever the CAL lamp is out, the sweep rate of the A sweep generator is uncalibrated.

4.2.5.2. The sweep rate of the A sweep generator is bracketed by the two black lines on the clear plastic inner flange of the A TIME/cm switch.

4.2.5.3. The sweep rate of the B sweep generator is indicated by the white engraved line on the B TIME/cm sweep knob. The B sweep rate can be changed without altering the setting of the A sweep generator.

4.2.6. B. Sweep Selection

4.2.6.1. The 'B' sweep is operable in the 'A Marked by B' and 'B Delayed by A' positions of the sweep mode switch. The 'A' sweep rate, along with DELAY helipot dial, determines the time that the B sweep is delayed. The sweep rate of the delayed portion is determined by the B TIME/cm switch setting.

(a) ***A MARKED BY B position.*** In this mode, the display will appear similar to that shown in fig. 4.7. The amount of delay time between the start of the A sweep and the 'marked' (intensified) portion is determined by the setting of the A TIME/cm switch and the DELAY helipot dial. For example, the delay time indicated by the DELAY helipot dial shown in fig. 4.6 is 2.9. This corresponds to 2.9 graticule positions of the A sweep This reading, multiplied by the setting of the A TIME/cm switch gives the calibrated delay time before the start of the B sweep (i.e. the delay time in fig. 4.8 is 2.9 ms).

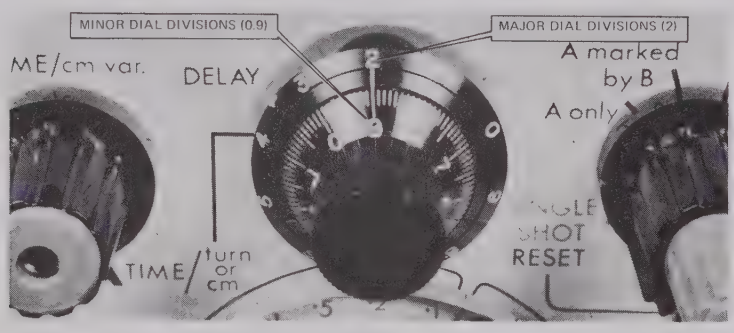


FIG. 4.6. DELAY HELIPOT DIAL (READING SHOWN 2.9.)

The 'marked' portion of the display is produced by the B sweep. The length of this portion is about 11 times the setting of the B TIME/cm switch.

When the sweep mode selector is set to 'B DELAYED BY A' only the marked (intensified) portion (as viewed in the 'A MARKED BY B' position) is displayed on the screen at the sweep rate indicated by the B TIME/cm switch (see fig. 4.8).

(b) ***'B DELAYED BY A' position.*** This provides two modes of delayed sweep. Fig. 4-9 illustrates the difference between these two modes. With the GATED switch pushed-in, the B sweep is presented immediately after the delay time (fig. 4-9A). The B sweep is triggered at a selected level on the A sweep to provide a delay for the B sweep. Since this delay time is the same for each sweep, the display appears stable. With the GATED switch pulled-out, the B sweep operates only when it is triggered after the selected delay time (see fig. 4.9B). The B triggering controls operate in the same way as the A controls.

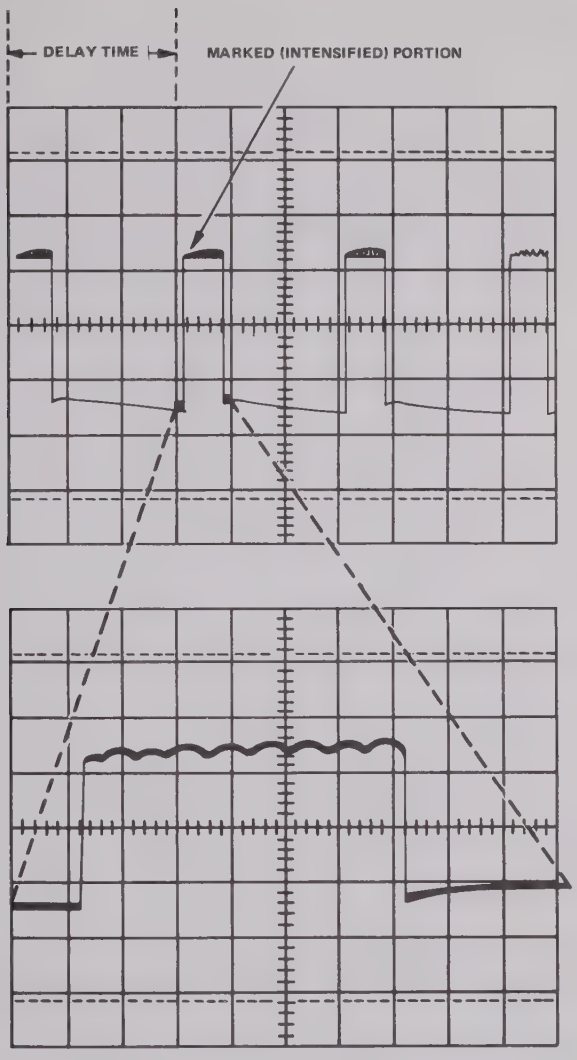


FIG. 4.7. 'A MARKED BY B' DISPLAY
(A TIME/cm, 1 cm, B TIME/cm, 0.1 ms)

FIG. 4.8. 'B DELAYED BY A' DISPLAY

(c) ***Delayed Sweep Operation.*** To obtain a delayed sweep display use the following precedure:—

(i) Set the sweep mode selector to 'A MARKED BY B'.

(ii) Set the GATED switch to the desired position. If GATED is used (knob pulled-out), correct B triggering is also necessary.

(iii) Set the delay time with the A TIME/cm switch and the DELAY helipot.

(iv) Pull the B SWEEP (B TIME/cm) knob out and set it to the required sweep rate.

(v) If GATED is used, check the display for an intensified portion. Absence of this indicates that the B sweep is not correctly triggered.

(vi) Set the sweep mode selector to 'A DELAYED BY B'. The intensified area shown in the 'A MARKED BY B' position is now displayed at the sweep rate selected by the B TIME/cm switch.

(d) ***Mixed Sweep Mode Operation.*** The MIXED mode is used when it is requred to view both A and B sweeps simultaneously. The mixed mode display is formed as shown in fig. 4-10 A, B and C.

4.2.7. SLOPE (A and B Sweeps)

(a) The SLOPE switch determines the slope (+ : positive-going, — : negative-going) of the trigger signal on which

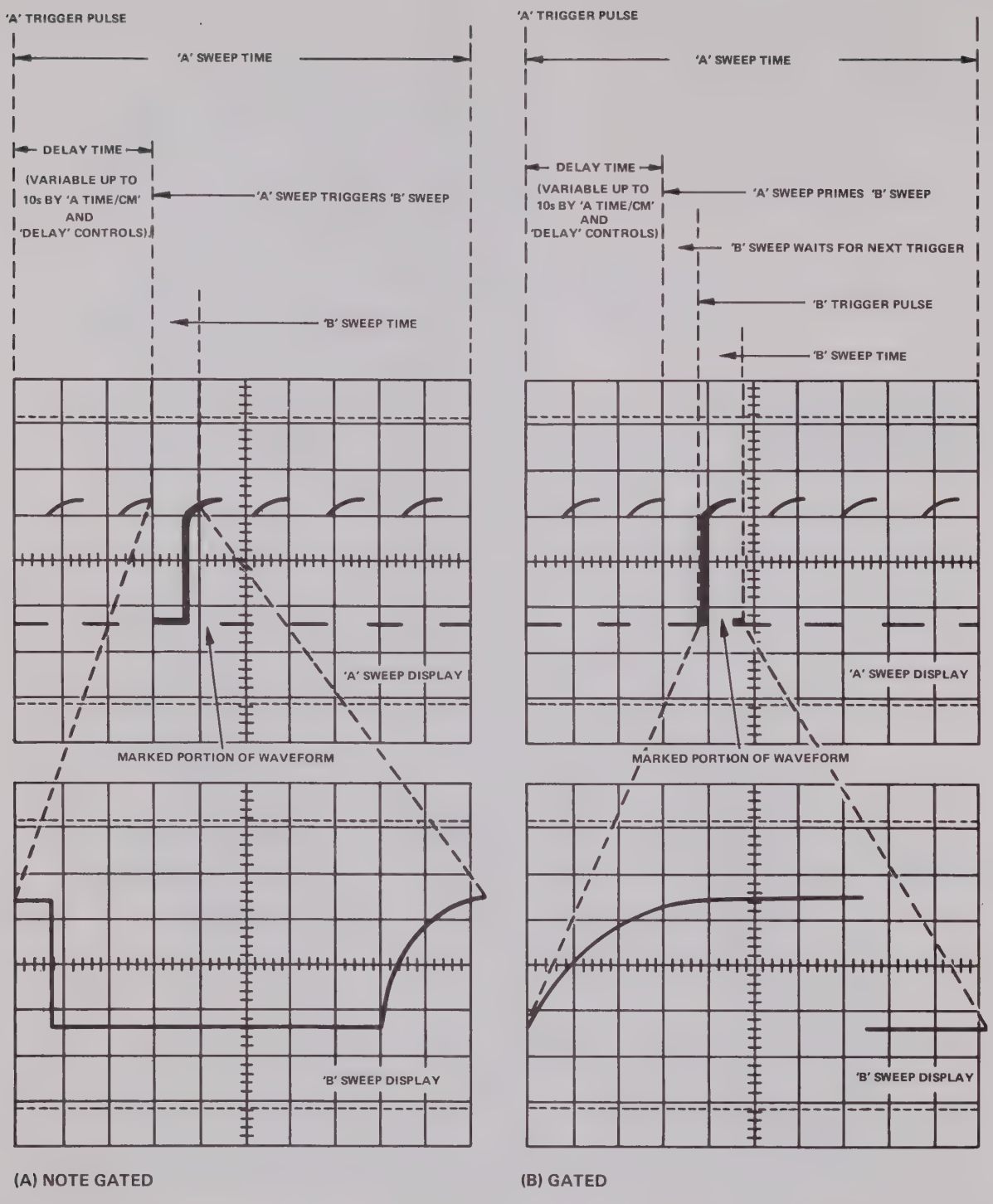


FIG. 4.9. COMPARISON OF DELAYED SWEEP MODES

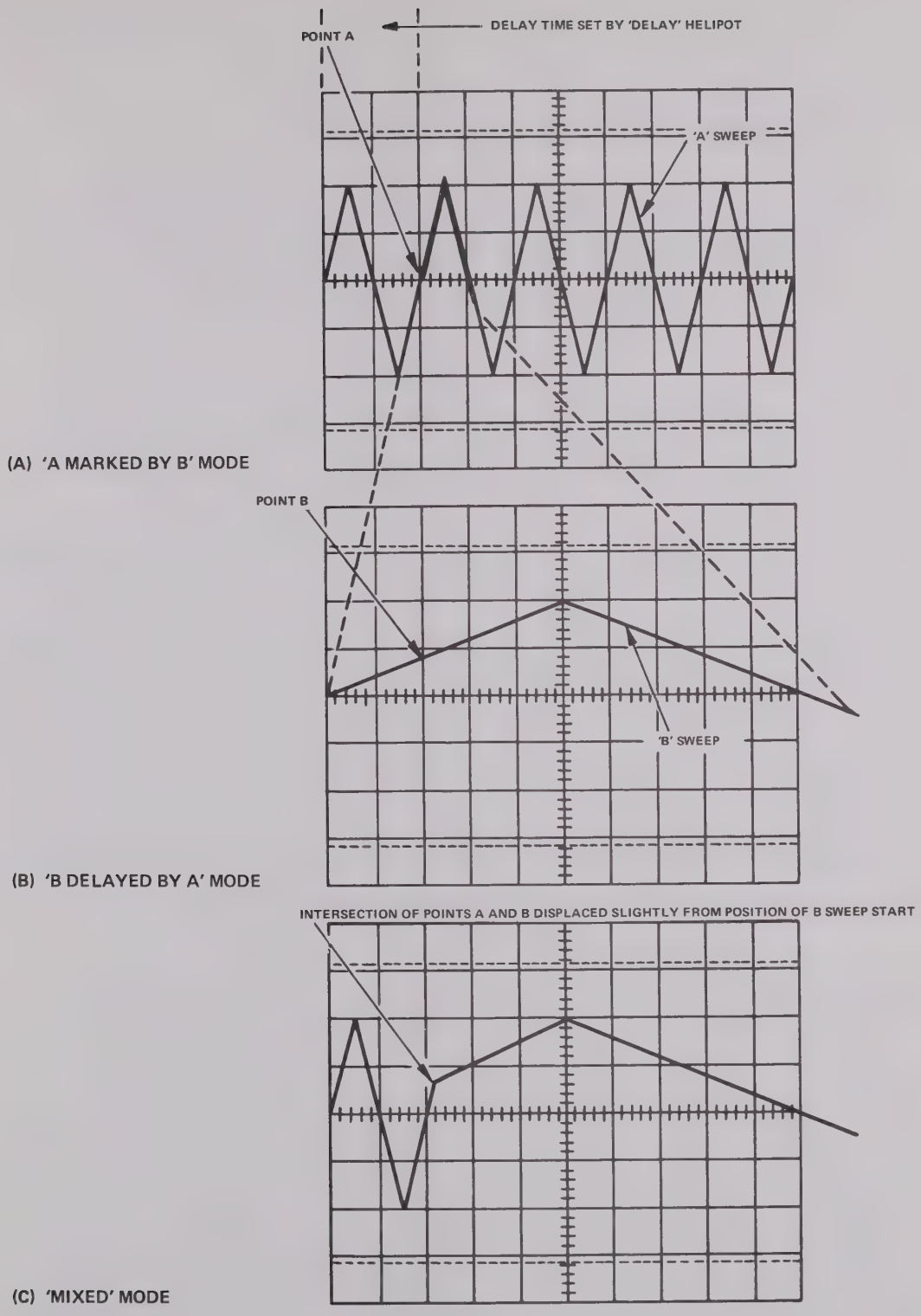

DELAY TIME SET BY 'DELAY' HELIPOT
POINT A
'A' SWEEP
(A) 'A MARKED BY B' MODE
POINT B
'B' SWEEP
(B) 'B DELAYED BY A' MODE
INTERSECTION OF POINTS A AND B DISPLACED SLIGHTLY FROM POSITION OF B SWEEP START
(C) 'MIXED' MODE

FIG. 4.10. FORMATION OF MIXED DISPLAY

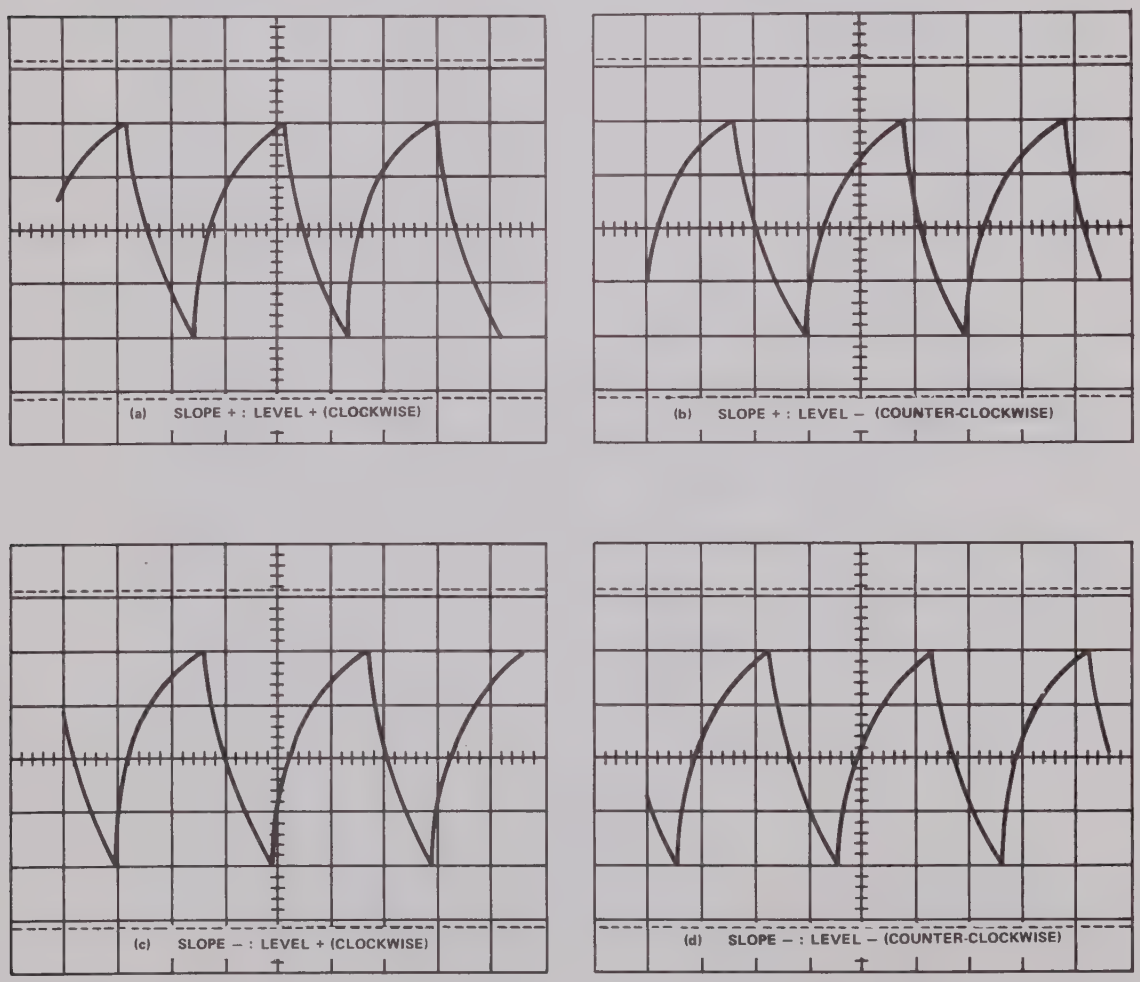
the trigger circuit responds. If several periods of a signal are to be displayed, the setting of the SLOPE switch is not necessarily important. However, if only a portion of a signal is to be displayed, the SLOPE switch must be correctly set to provide the desired display.

4.2.8. **Trigger LEVEL (A and B Sweeps)**

(a) The LEVEL control permits the sweep to be initiated on the selection of the trigger signal. Clockwise rotation of the control causes the trigger circuit to respond at a more positive point on the trigger signal; counter-clockwise rotation causes the trigger circuit to respond at a more negative point. The control should be adjusted once the TRIG SOURCE, SLOPE and TRIG MODE switches have been set.

4.2.9. **HF SYNC (High-Frequency Stability)**

(a) If a sweep trigger occurs near the instant the sweep hold-off period ends (e.g. at triggering frequencies of 5 MHz or more), then the hold-off period can be adjusted with the HF SYNC control to obtain a stable display. This control can also be used when the trigger signal is complex, as in digital systems, to adjust the repetitic rate of the sweep to coincide with that of the trigger input.



The B triggering controls operate in the same way as the A controls.

FIG. 4.11. EFFECT OF TRIGGER SLOPE AND LEVEL ON THE TRIGGER POINT

4.2.10. SINGLE SHOT Facility

(a) When the signal to be displayed is not repetitive or varies in amplitude, shape or time, a conventional repetitive display may produce an unstable presentation. To avoid this, the single-shot facility can also be used to photograph a non-repetitive signal.

(b) To use this facility, make sure that the trigger circuit will respond to the event to be displayed, and obtain the best possible display in the normal manner. For random signals, set the trigger circuit to trigger on a signal which is about the same frequency and amplitude as the random signal. Now, set the 'red' HF SYNC control to the SINGLE SHOT position and press the RESET button.

(c) With the RESET button pressed, the next trigger pulse initiates the sweep and a single trace will be displayed. After completion of this sweep, the A sweep generator is 'locked-out' until reset. The RESET lamp lights-up when the A sweep generator circuit has been reset and is ready to produce a sweep. The lamp is extinguished on completion of the sweep. The RESET button is pressed again to obtain another single-shot display. If AUTO trigger is selected, the timebase will appear to trigger, immediately the RESET button is pressed. This is useful for checking that other controls, i.e., Y range, are correctly set.

4.3 X INPUT SWEEP SELECTION (SM 112 Main Frame)

(a) ***SWEEP Position.*** In the SWEEP mode, the sweep rate is controlled by the TIME/cm and x1 Pull x10 switches, the TIME/cm VAR control being set to the CAL position. When Pull x10 switch is set to x10 the sweep rate is determined by dividing the TIME/cm switch setting by 10. For example, if the switch is set to 50 µs, the magnified sweep rate is 5 µs/cm.

(b) ***External Sweep.*** In the EXT DC or EXT AC modes, the X deflection is determined by a signal applied to the X IN connection. The choice of a.c. or d.c. coupling is dependent upon the content of the input waveform: d.c. coupling is suitable for most inputs, especially if the frequency of the a.c. component is below 10 Hz – in the EXT AC mode attenuation of components below 10 Hz occurs. However, if the signal contains a large d.c. component, the EXT AC mode should be used, otherwise the d.c. offset in the X-deflection will be beyond the range of the SHIFT control. The sensitivity of the sweep on external input is 1 V/cm approximately, when the Pull x10 switch is set to x1. For large amplitude inputs therefore, only the first 10 V approximately will form the effective sweep, the horizontal SHIFT controls being adjusted as necessary. At the x10 position, the Pull x10 switch multiplies the input sensitivity by a factor of 10.

(c) ***X SHIFT Controls.*** The horizontal position of the sweep can be set by the COARSE SHIFT Control, which provides at least 20 cm of control. The FINE SHIFT Control has a range of approximately 2 cm.

4.4 Z IN FACILITY

If an external signal is available (3-volts peak-to-peak minimum) the function of the Z-modulation circuit can be demonstrated:–

(a) Connect the external signal to ***both*** the CH1 connector and the Z IN socket.

(b) Set the TIME/cm swtich to display about five cycles of the waveform. The positive peaks of the waveform should be blanked and the negative peaks intensified, indicating intensity modulation.

4.5 VERTICAL DEFLECTION MODES (SM 599)

(a) ***CH1 Mode.*** In the CH1 position of the Mode Selector, the display is single beam and CH1 signals only are

displayed. If the A trigger mode selected is CH2 or EXT, a stable display will only be obtained if the channel 2 or external triggering signal is time related to the channel 1 signal.

(b) ***CH2 Mode.*** In the CH2 position of the Mode Selector, the display is single beam and CH2 signals only are displayed. If the A trigger mode selected is CH1 or EXT, a stable display will only be obtained if the channel 1 or external triggering signal is time related to the channel 2 signal.

(c) ***Alternative Mode.*** The ALT position of the Mode Selector produces a display which alternates between channel 1 and channel 2 with each timebase sweep, the sweep being triggered as selected by the A TRIG MODE switch. The signals on both channels, if time-related, are displayed showing true time relationship. However, if the signals are not time related, then the waveform not related to the selected triggering signal, will not be synchronised. The ALT mode can be used at all sweep rates, but at sweep rates below about 20 ms/cm, alternate mode switching becomes visually perceptible.

(d) ***Chopped Mode.*** The CHOP position of the Mode Selector produces a display that is switched at approximately 200 kHz, between the two channels. The CHOP mode provides a more satisfactory display than the ALT mode at sweep rates slower than about 20 ms/cm, or whenever a dual trace, single-shot event is to be displayed. At sweep rates faster than 20 ms/cm. due to only chopped 2 µs portions of the signals being displayed, the chopped switching becomes perceptible and may interfere with the display. The signals on each channel, if time related, are displayed showing true time relationship. However, if the signals are not time related, then the waveform not time related to the selected triggering, will not be synchronised. The trigger bandwidth is reduced in this mode to prevent triggering on the spurious chopping signals.

(e) ***CH1 +2 Mode.*** The CH1 +2 position of the Mode selector can be used:—

(i) to display the sum or difference of two signals.
(ii) to remove an unwanted signal by common mode rejection.
The PULL TO INVERT switch in channel 2 can be used to facilitate these uses. The overall deflection sensitivity in the CH1 +2 mode when both V/cm switches are set to the same position is the same as the deflection sensitivity indicated by either switch. This also provides a similar response from each channel. However, if the CH1 and CH2 V/cm switches are set to different deflection sensitivities, the resultant waveform amplitude can only be determined accurately if the amplitude of the signal applied to either channel is known. To ensure the optimum deflection range for this mode, the CH1 and CH2 SHIFT controls should be set to position the signal on each channel to mid-screen, the mode selector being set to CH1, then CH2 respectively.
NOTE: The rejection ratio can be set to any value by applying the same signal to both inputs simultaneously and then adjusting one or both fine gain controls to minimise the deflection.

4.6 X-Y OPERATION

(a) To display two signals against each other rather than against time, a signal applied to X IN provides a method of applying an external signal to the X-amplifier, the X Input Selector (on the main frame) being set to EXT DC or A as required. The vertical deflection is obtained by applying a signal to either CH1 IN or CH2 IN. The horizontal SHIFT controls provide X-axis position and the appropriate vertical SHIFT control provides Y-axis position.

(b) The type of display required determines the mode of input coupling used. The EXT DC coupling can be used for most applications but if the d.c. component of the signal is much larger than the a.c. component, EXT AC coupling should be used. EXT DC coupling should be used to display a.c. signal below about 10 Hz as attenuation and phase shift of these signals, due to the blocking capacitor in the input circuit, occurs in the EXT AC position.

(c) The X-Y type of display can be used to measure the phase difference between two signals of the same frequency, if this frequency is below approximately 70 kHz. Above this frequency, the effect of the 160 ns delay line in the vertical deflection channel causes the measurement to become inaccurate.

4.7 CALIBRATOR

(a) The calibrator provides a convenient voltage source for checking the performance of the horizontal and vertical deflection systems. It can also be used as a signal source for external equipment and provides accurate, 3 mV to 30 V peak-to-peak (in a 1, 3, 10 sequence) squarewave outputs into a high impedance load at a frequency of 1 kHz. A +30 V d.c. position is provided so that the output can be checked on a digital voltmeter.

5. BASIC APPLICATIONS

NOTE: These applications are for guidance only and each must be adapted to a specific measurement.

5.1 VOLTAGE MEASUREMENT

(a) A.C. Measurement.

This procedure can be used to measure the peak-to-peak amplitude of a waveform or between two points (in amplitude) on the waveform:

(i) Connect the signal to CH1 IN and set the input coupling to AC.

NOTE: If the frequency of the signal is below about 50 Hz, set the input coupling to DC.

(ii) Set the vertical Mode Selector to CH1, CH1 V/cm FINE to CAL, and CH1 V/cm for a deflection of approximately 6 cm.

(iii) Adjust the trigger controls to obtain a stable display and set TIME/cm so that several cycles are displayed.

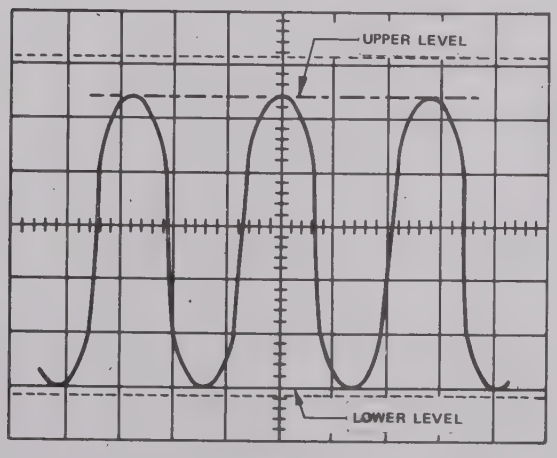


FIG. 4-12 MEASUREMENT OF AC VOLTAGES

(iv) Adjust CH1 SHIFT to position the lower point to be measured on a horizontal graticule line on the lower half of the screen.

(v) Adjust SHIFT (COARSE and FINE) to position the upper point to be measured on the centre vertical graticule line.

(vi) Note the required amplitude (in cm): to obtain the amplitude in volts, multiply this by the V/cm setting, and the attenuation factor of any probe used.

Example

In Fig. 4-12, the peak-to-peak amplitude of the indicated waveform is 5.4 cm. If the V/cm setting is 5 V/cm, then the waveform amplitude is 27 V.

(b) **DC Measurement (Fig. 4-13).**

This procedure may be used to measure an instantaneous d.c. voltage or a d.c. level with respect to ground or with respect to a voltage other than ground.

(i) Connect the signal to CH1 IN and set vertical Mode Selector to CH1, CH1 V/cm FINE to CAL, and V/cm for a deflection of approximately 6 cm.

(ii) Set the CH1 input coupling to GND and select AUTO trigger.

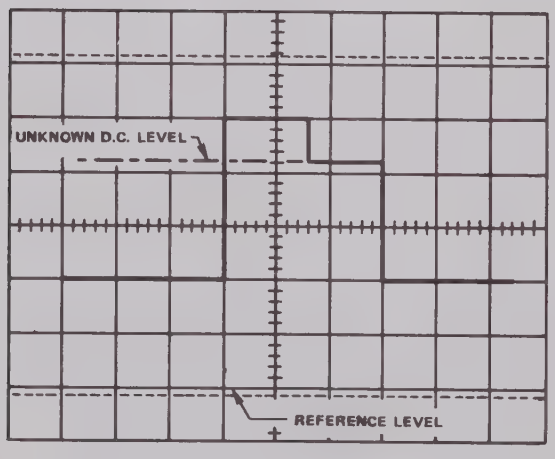


FIG. 4-13 MEASUREMENT OF DC VOLTAGES

(iii) If the voltage to be measured is positive with respect to ground, adjust CH1 SHIFT to position the trace on the bottom horizontal graticule line or other reference line. If the voltage is negative with respect to ground, position the trace on the top horizontal graticule line.

NOTE: To measure with respect to a voltage other than ground, disconnect the signal from CH1 IN, set input coupling to DC,and apply the reference voltage to CH1 IN. Position the trace to a reference horizontal graticule line. Disconnect the reference voltage and reconnect the signal.

(iv) Set CH1 input coupling to DC. Select CH1 trigger and adjust TIME/cm and trigger controls for a stable display of several cycles.

(v) Note the distance in centimetres between the reference line and the required point on the signal, and note the polarity. To obtain the amplitude in volts, multiply the distance by the V/cm setting and the attenuation factor of any probe used.

Example

In Fig. 4-13 the distance between the reference level and the required level on the indicated waveform is 4.2 cm (positive) . If the V/cm setting is 2 V/cm, then the required level is 8.4 V positive with respect to the reference voltage.

(c) **Comparison of Voltages**

Where it is necessary to compare the amplitude of a signal with that of an a.c. reference signal, a deflection sensitivity, different from those indicated on the V/cm switch, may be required. The following procedure can be used to obtain the relevant sensitivity:

(i) Connect the reference signal of known amplitude to CH1 IN, and select CH1 vertical Mode Selector and CH1 TRIG MODE.

(ii) Adjust V/cm and V/cm FINE for an exact number of centimetres of vertical deflection. Maintain this V/cm FINE setting. If necessary, adjust the trigger controls for a stable display.

(iii) Calculate the vertical conversion coefficient (V.C.C.) where,

$$\text{V.C.C.} = \frac{\text{Amplitude of reference voltage (volts)}}{\text{V/cm setting x deflection (cm)}}$$

(iv) Calculate the effective deflection sensitivity (E.D.S.) where,

$$\text{E.D.S.} = \text{V/cm setting x V.C.C.}$$

(v) Disconnect the reference signal and connect the input signal.

(vi) If necessary, reset V/cm only, for an adequate deflection and re-adjust the trigger controls for a stable display.

(vii) Note the vertical deflection. To calculate the signal amplitude in volts:—

$$\text{Signal Amplitude} = \text{E.D.S. x deflection (cm)}$$

5.2 TIME MEASUREMENT

(a) **Time Duration (Fig. 4-14).**

(i) Connect the signal to CH1 IN and set TRIG MODE and vertical MODE to CH1.

(ii) Set TIME/cm VAR to CAL and adjust TIME/cm so that the maximum distance between the points to be measured is approximately eight cm.

(iii) Adjust CH1 SHIFT to position the points on the centre horizontal graticule line, if convenient to do so.

(iv) Adjust ⟷ SHIFT to position one point on the intersection of a vertical and the horizontal graticule lines.

(v) Note the distance (in cm) between the points . Multiply this by the TIME/cm setting (and divide by 10 if the Pull x10 setting is used) to obtain the required time interval.

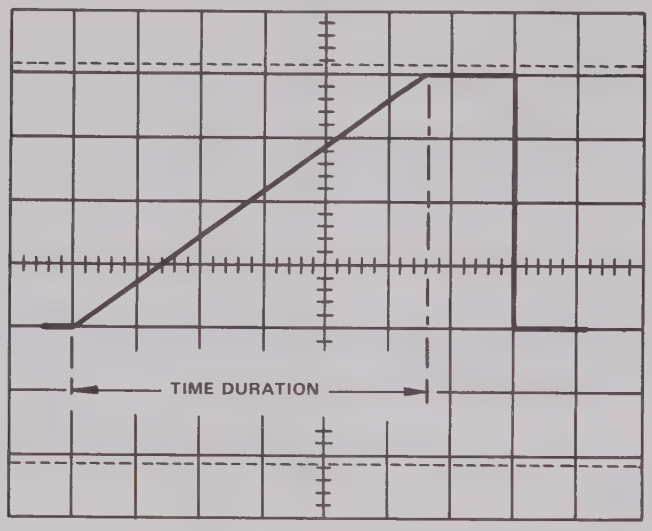


FIG. 4-14 MEASUREMENT OF TIME DURATION

Example

In Fig. 4-14, the distance between the two points is 5.6 cm. If the TIME/cm setting is 20 μs/cm and Pull x10 is selected, the time interval is 11.2 μs.

(b) **Frequency Measurement.**

The frequency of a periodically-recurrent signal is the reciprocal of the time duration of one cycle.

(i) Measure the time duration of one cycle.

(ii) Take the reciprocal to determine the frequency.

(c) **Rise-Time (Fig. 4-15)**

Measurement of rise-time is similar to the procedure detailed in Para 5.2 (a), the interval being between the 10% and 90% points on the leading edge of the waveform. Fall-time is measured on the trailing edge of the waveform.

(i) Connect the signal to CH1 IN and set TRIG MODE and vertical Mode Selector to CH1.

(ii) Set V/cm and V/cm FINE so that the vertical deflection is exactly 8 centimetres: this allows use of the 10% and 90% dotted lines on the graticule. If necessary, adjust SLOPE and trigger controls so that all of the leading edge is displayed.

(iii) Set TIME/cm FINE to CAL and adjust TIME/cm so that the maximum duration of the rise-time is approximately eight cm.

(iv) Determine the 10% and 90% points. Adjust the SHIFT so that the 10% point lies on a vertical graticule line.

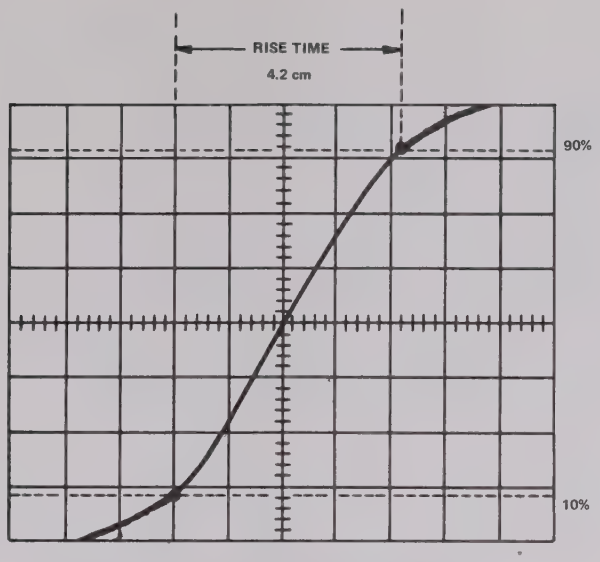


FIG. 4-15 MEASUREMENT OF RISE TIME

(v) Note the horizontal distance (in cm) between the 10% and 90% points (as shown by the dotted lines on the graticule). Multiply this by the TIME/cm setting (and divide by 10 if the Pull x10 setting is used) to obtain the rise-time.

Example:

In Fig 4-15, the distance between the 10% and 90% points is 4.2 cm. If the TIME/cm setting is 0.5 µs/cm, the rise-time is 2.1 µs.

(d) **Time Difference– Dual-Trace Operation (Fig. 4-16.)**

The dual-trace facility allows the time difference between two separate time-related events to be measured. The sweep must be triggered from the signal which occurs first (e.g. a system trigger) and, if possible, co-axial cables of equal length should be used to connect the signals to the two vertical channels, thus minimising any delay errors.

(i) Set vertical Mode Selector to CHOP or ALT, and CH1 and CH2 input coupling as required.

(ii) Set A TRIG MODE to CH1. Connect the reference signal to CH1 IN and the comparison signal to CH2 IN.

(iii) Adjust CH1 and CH2 V/cm for display amplitudes of 5 cm to 6 cm, and adjust the trigger controls for a stable display.

(iv) Set TIME/cm FINE to CAL and adjust TIME/cm so that the interval between the two points can be measured.

(v) Adjust CH1 and CH2 SHIFT so that the points to be measured lie on the centre horizontal graticule line. Adjust ⟷ SHIFT so that one point lies on the intersection of the horizontal and vertical graticule line.

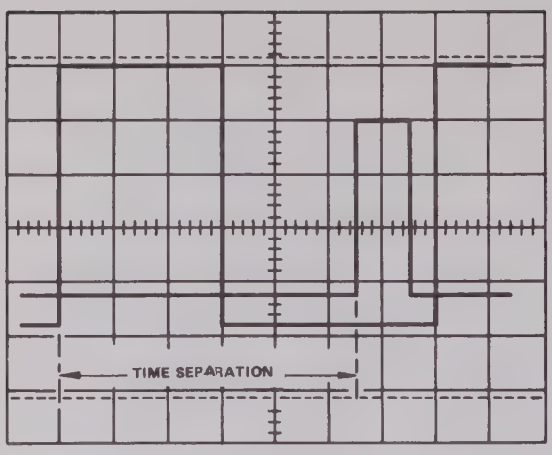


FIG. 4-16 MEASUREMENT OF TIME DIFFERENCE (Dual Trace Operation)

(vi) Note the horizontal distance (in cm) between the two points. Multiply this by the TIME/cm setting (and divide by 10 if the Pull x10 setting is used) to obtain the time difference.

Example

In Fig 4-16 the distance between the two points is 5.5 cm. If the TIME/cm setting is 2 µs/cm, the time difference is 11 µs.

(e) Phase Difference — Dual Trace Operation (Fig. 4-17)

If the phase difference between two time-related signals of the same frequency is required, the dual-trace application of measure time difference can be used.

(i) Proceed as in the ***time-difference*** application, but adjust TIME/cm and TIME/cm FINE so that the CH1 signal occupies exactly eight centimetres. Each of these eight centimetres represents 45 deg of the cycle, i.e. the effective sweep rate is 45 deg/cm.

NOTE: If the signals are of opposite phase, PULL TO INVERT CH2, and take this 180 deg change on CH2 into account when calculating the phase difference in the next step.

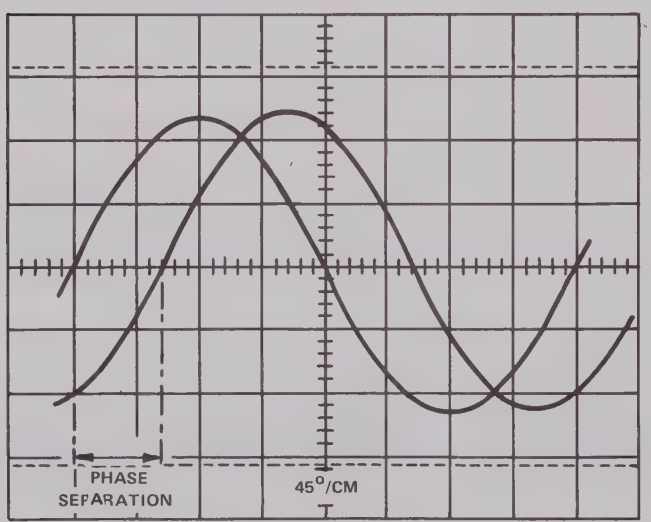


FIG. 4-17 MEASUREMENT OF PHASE DIFFERENCE (Dual Trace Operation)

(ii) Note the horizontal difference (in cm) between equivalent points on the two signals. Multiply this by 45 deg/cm to obtain the phase difference.

NOTE: A more accurate measurement can be obtained by switching to Pull x10 facility, once the cycle duration of eight centimetres is set. The effective sweep rate is then 9 deg/cm.

Example

In fig 4-17 the distance due to phase between the two signals is 1.4 cm. Thus the phase difference is 63 deg.

(f) **X-Y Operation (Figs. 4-18, 4-19)**

If the phase difference between two time-related signals of the same frequency is required, the following method can be used:

(i) Connect one signal to CH1 IN, the other to X IN.

(ii) Set CH1 and X input coupling to AC and EXT AC respectively.

NOTE: If the signal frequency is below approximately 10 Hz, select DC and EXT DC coupling.

(iii) Adjust CH1 V/cm for a vertical deflection of approximately 6 cm and adjust the amplitude of the X input signal for a horizontal deflection of approximately 8 cm, (set TIME/cm to x1 or x10 as convenient).

(iv) Centralise the display about the centre horizontal graticule line. With reference to Fig. 4-17, note the two distances A and B. Then the sine of the phase angle ϕ, between the two signals is given by, $\frac{A}{B}$

Example

In fig 4-18, A is 5.2 cm and B is 7.4 cm.

$$\frac{A}{B} = 0.704$$

$$= \sin \phi$$

$$\therefore \phi \triangleq 45 \text{ deg.}$$

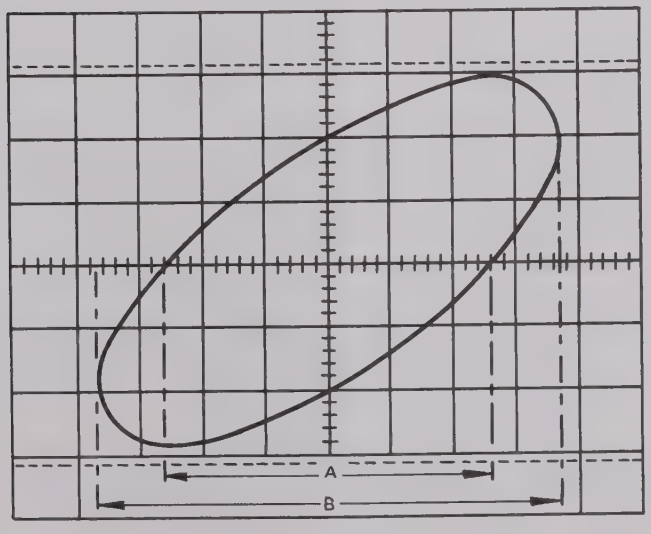


FIG. 4-18 MEASUREMENT OF PHASE DIFFERENCE (X-Y OPERATION)

NOTE: Fig. 4-19 shows several lissajous figures resulting from waveforms that have phase differences between 0 deg and 360 deg. Above 180 deg phase difference, it will be noticed that the lissajous figure for a particular phase angle is the same as that of some lower phase angle. Care should be taken, therefore, to obtain the correct phase angle from measurement.

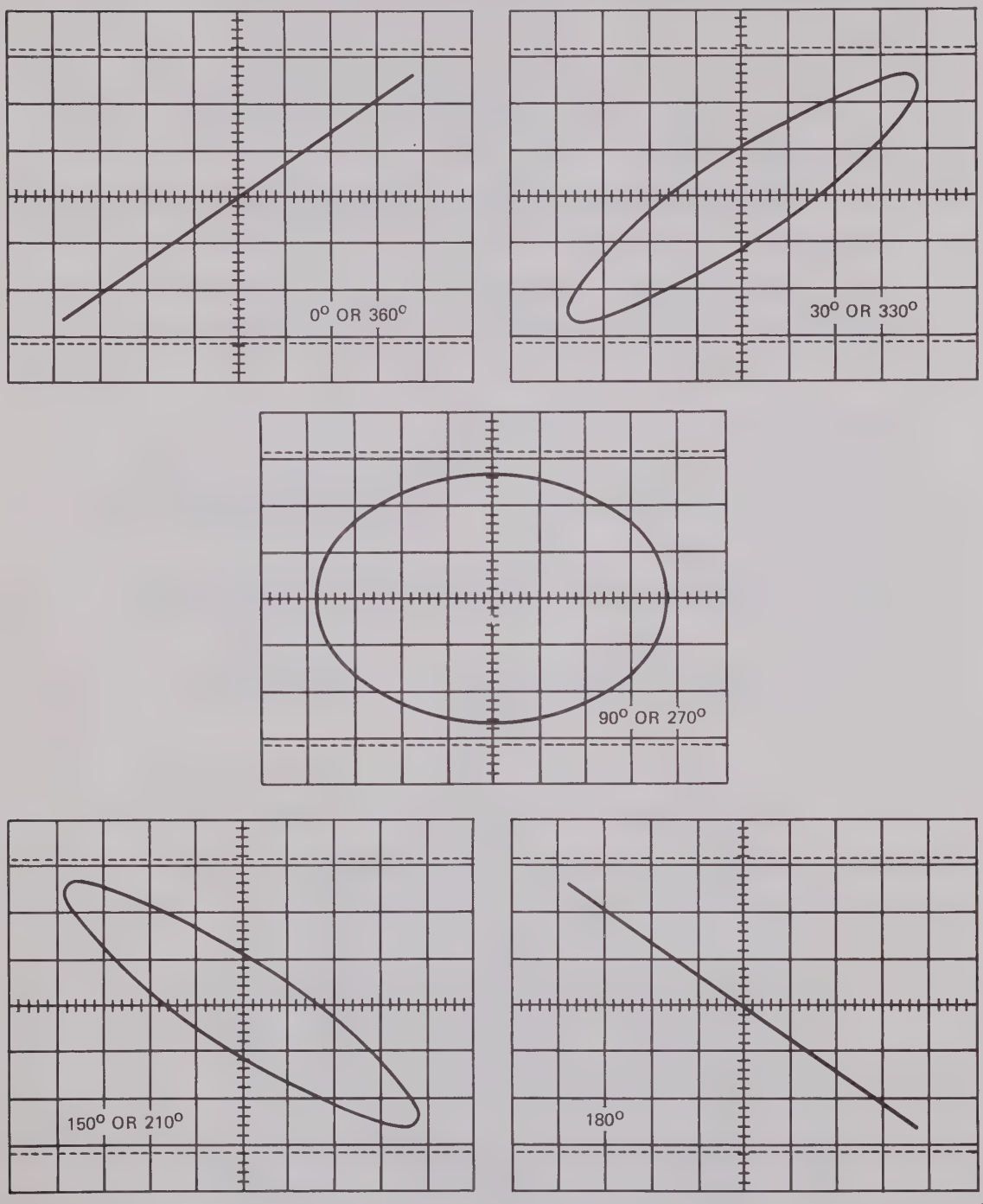


FIG. 4-19 TYPICAL LISSAJOUS FIGURES

5.3 COMMON MODE REJECTION

This procedure details a method of removing a line-frequency or similar component from a displayed waveform. The method for displaying the sum or difference of two signals is similar.

(i) Connect the signal containing the unwanted component to CH1 IN. Set TRIG MODE to CH1, vertical mode selector to ALT, input coupling to DC (AC if a large d.c. component is present).

(ii) Adjust CH1 V/cm for a deflection of approximately 5 cm and the trigger controls for a stable display.

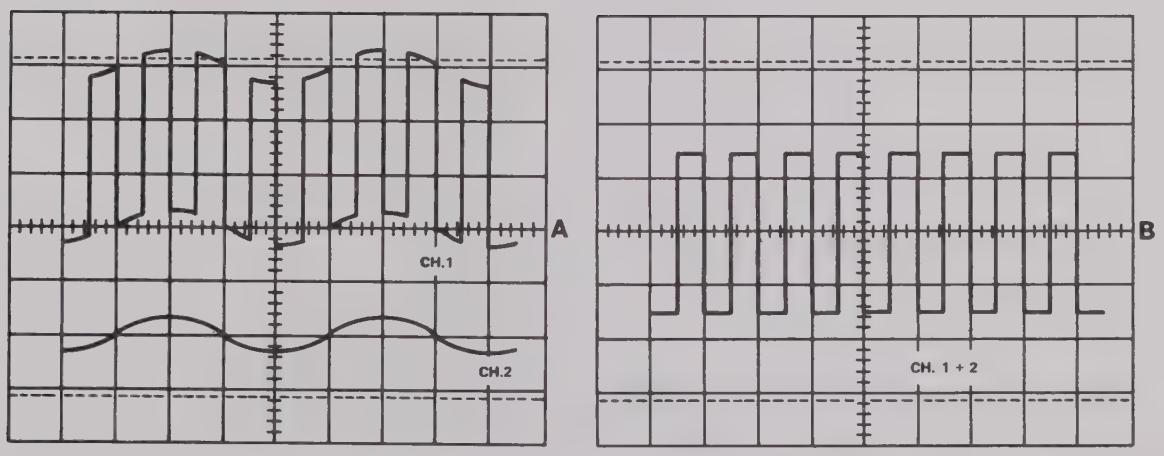


FIG. 4-20 EFFECT OF COMMON MODE REJECTION

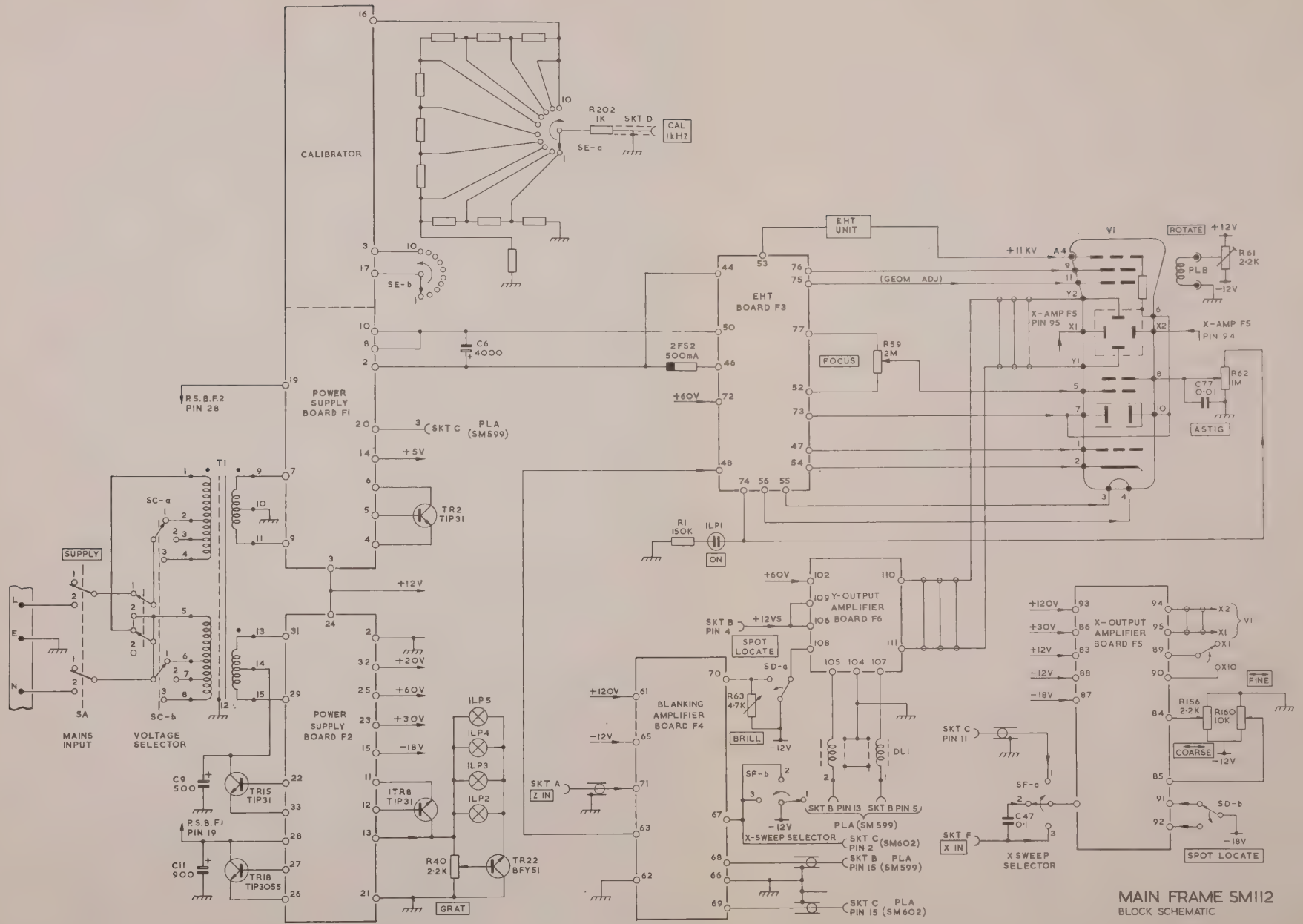
(iii) Connect a signal similar to the unwanted component of the CH1 signal to CH2 IN, input coupling to DC. Adjust CH2 V/cm for a deflection about equal to that of the unwanted signal apparent on the CH1 display.

(iv) Set vertical MODE selector to CH1 +2 and PULL TO INVERT CH2

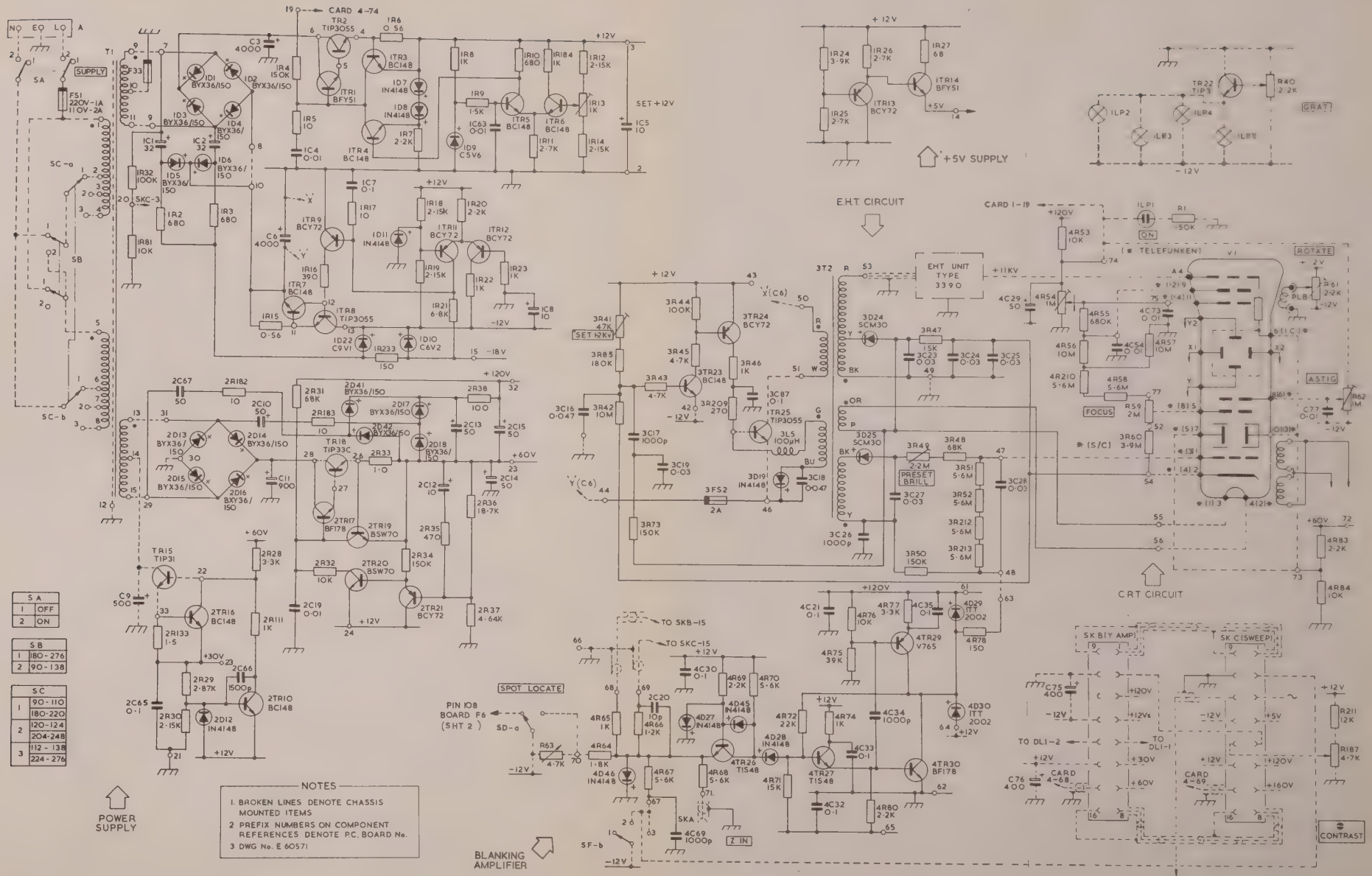
(v) Adjust CH2 V/cm and V/cm FINE for maximum cancellation of the unwanted signal

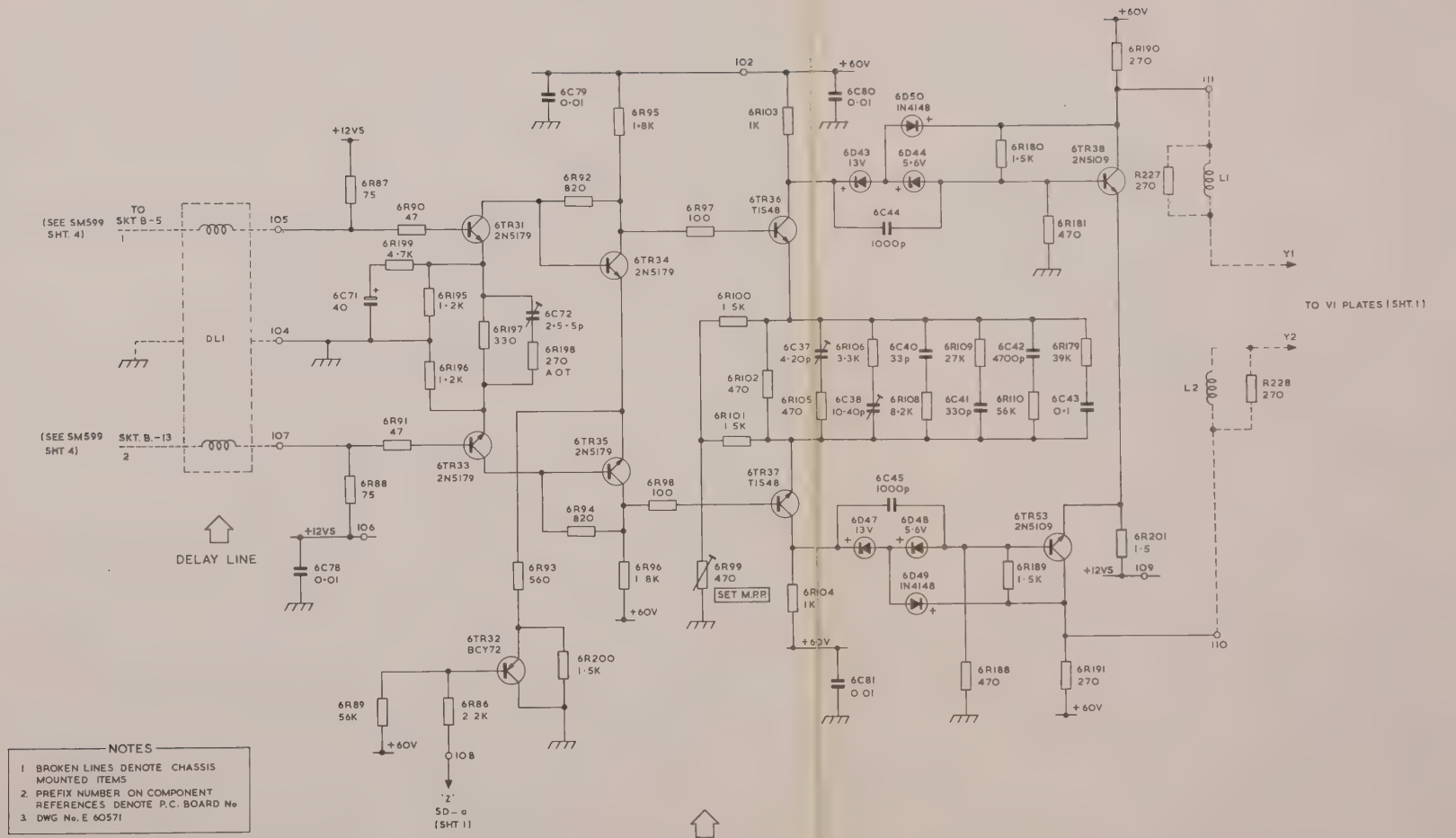
Example

Fig. 4-20 A shows the two signals displayed in the ALT vertical mode, and Fig 4-20 B shows the resultant cancellation in the CH1 +2, PULL TO INVERT vertical mode.



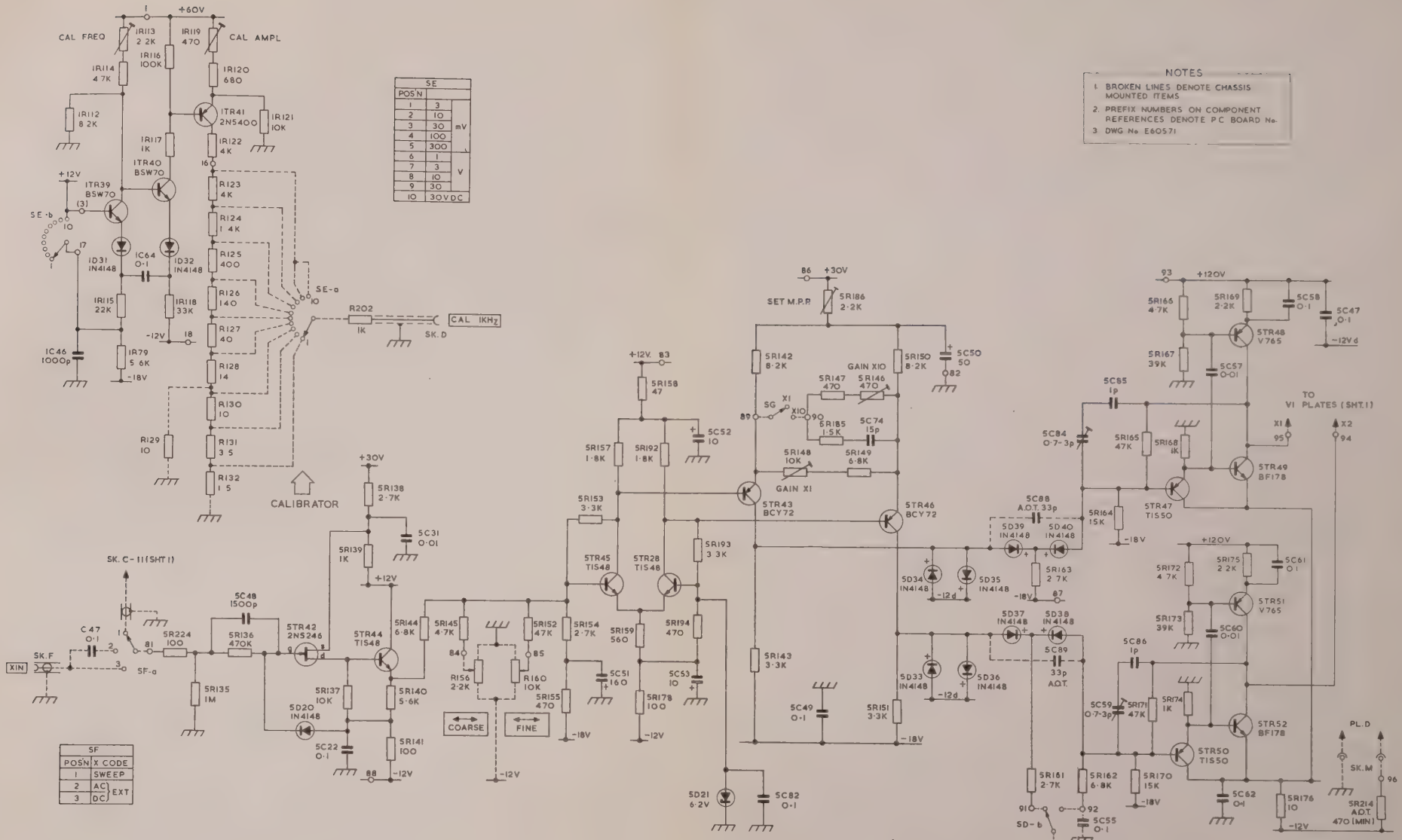
MAIN FRAME SM112
BLOCK SCHEMATIC

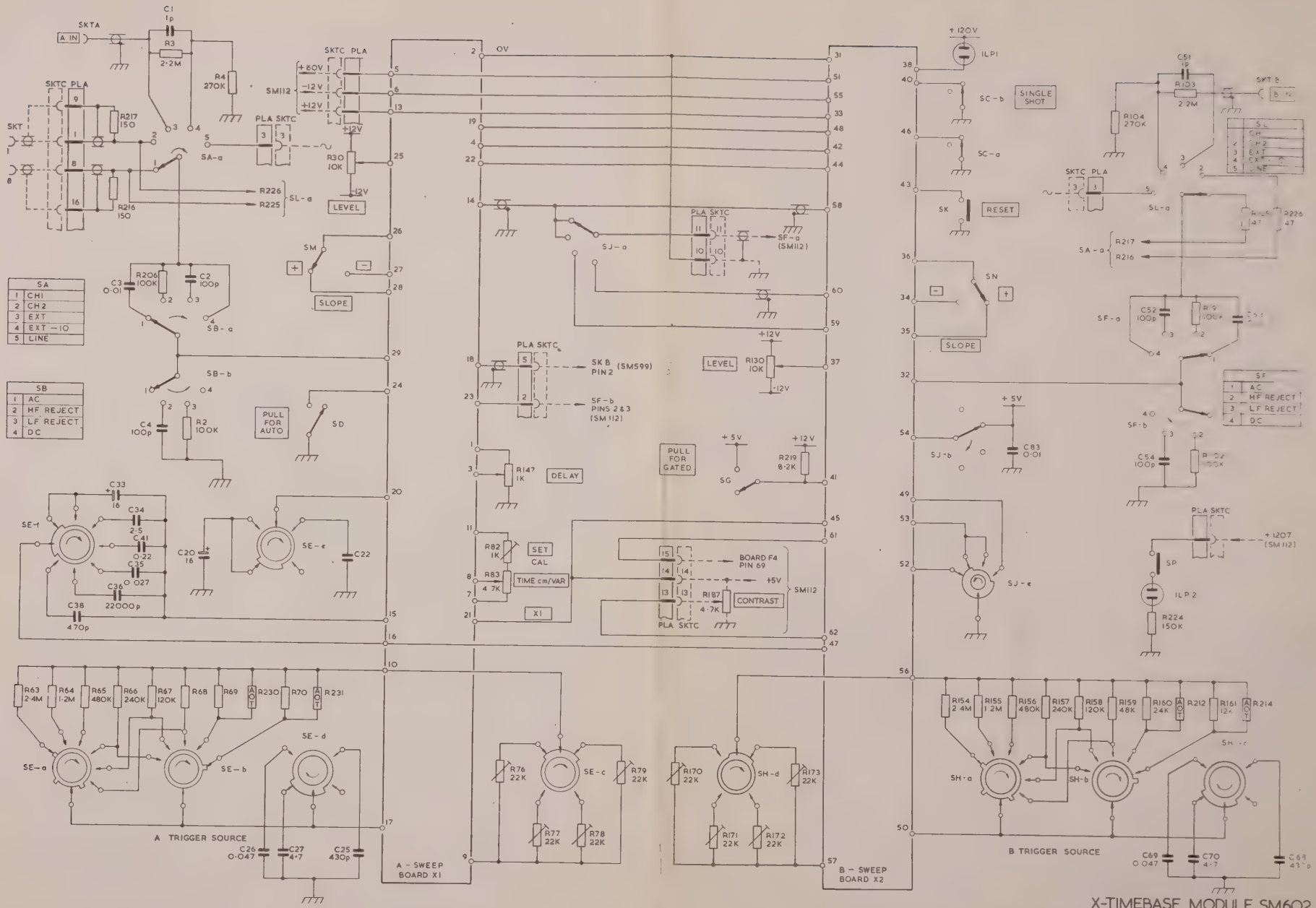

NOTES
1. BROKEN LINES DENOTE CHASSIS MOUNTED ITEMS
2 PREFIX NUMBERS ON COMPONENT REFERENCES DENOTE P.C. BOARD No.
3 DWG No. E 60571
POWER SUPPLY
BLANKING AMPLIFIER
E.H.T CIRCUIT
CRT CIRCUIT
+5V SUPPLY
EHT UNIT TYPE 3390
MAIN FRAME SM112
CIRCUIT DIAGRAM (SHT.1)
POWER SUPPLIES AND CRT CIRCUIT



MAIN FRAME SM112

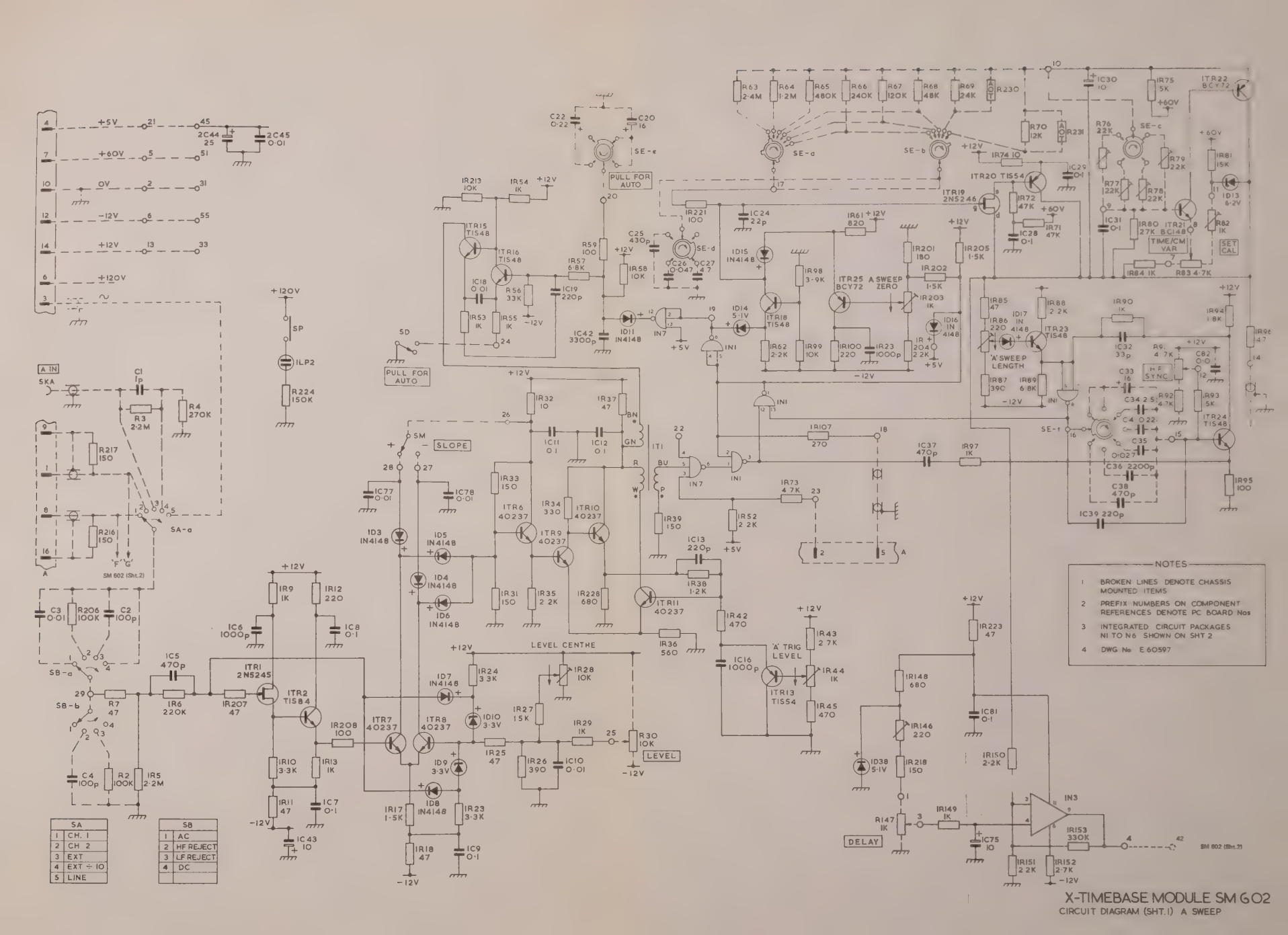
CIRCUIT DIAGRAM (SHT 2)
Y OUTPUT AMPLIFIER

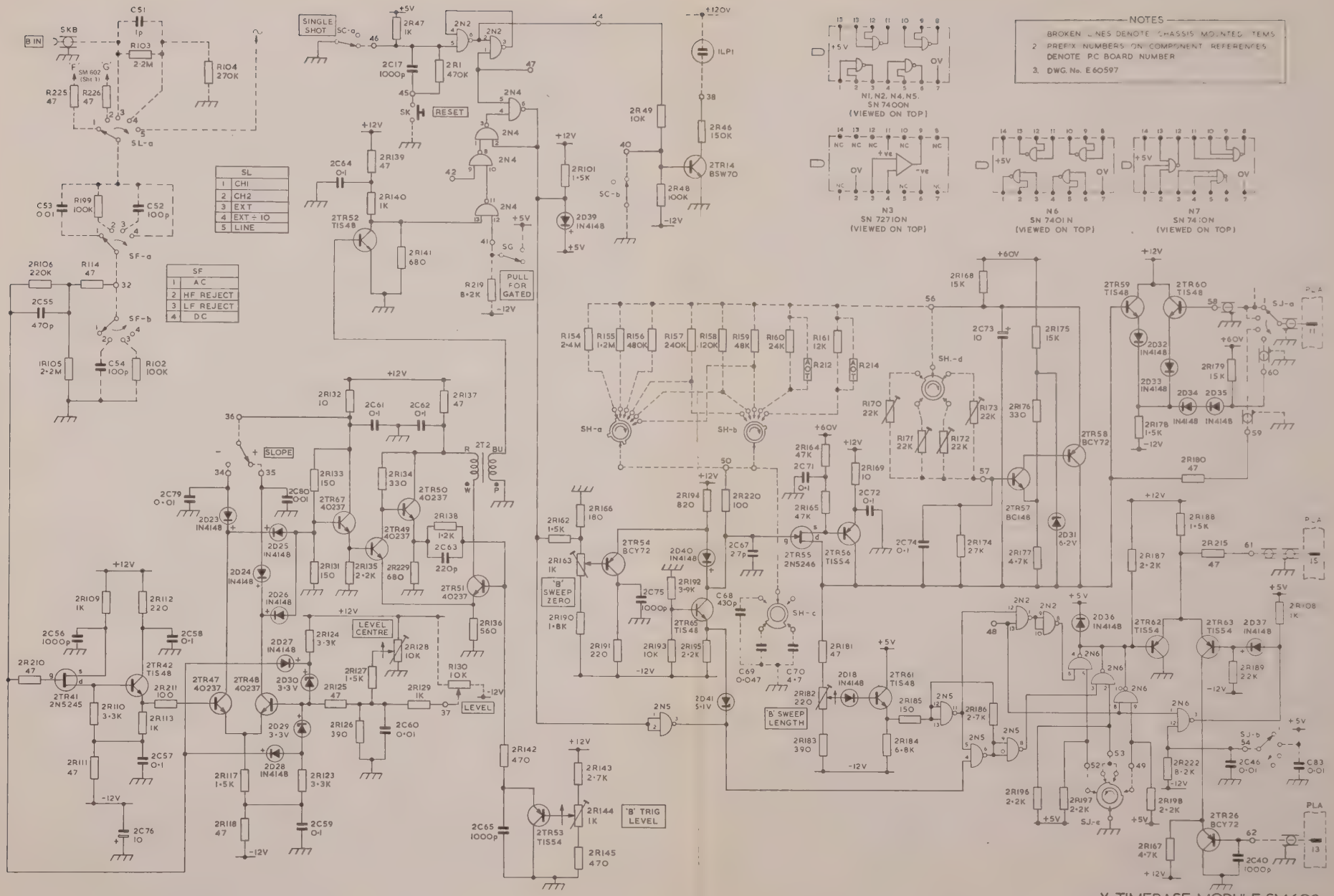

NOTES
1. BROKEN LINES DENOTE CHASSIS MOUNTED ITEMS
2. PREFIX NUMBERS ON COMPONENT REFERENCES DENOTE P.C. BOARD No.
3. DWG No. E60571
SE
POS'N
1 3
2 10
3 30 mV
4 100
5 300
6 1
7 3
8 10
9 30
10 30V DC
SF
POS'N X CODE
1 SWEEP
2 AC EXT
3 DC
CAL FREQ
CAL AMPL
+60V
+12V
-12V
-18V
+30V
CALIBRATOR
CAL 1KHz
SK.D
SK.C-II (SHT 1)
SK.F
XIN
SE-a
SE-b
SF-a
SET M.P.P.
GAIN X10
GAIN X1
SG
X1
X10
COARSE
FINE
SK.M
PL.D
TO V1 PLATES (SHT 1)
X-OUTPUT AMPLIFIER
MAIN FRAME SM112
CIRCUIT DIAGRAM (SHT 3)
X OUTPUT AMPLIFIER AND CALIBRATOR

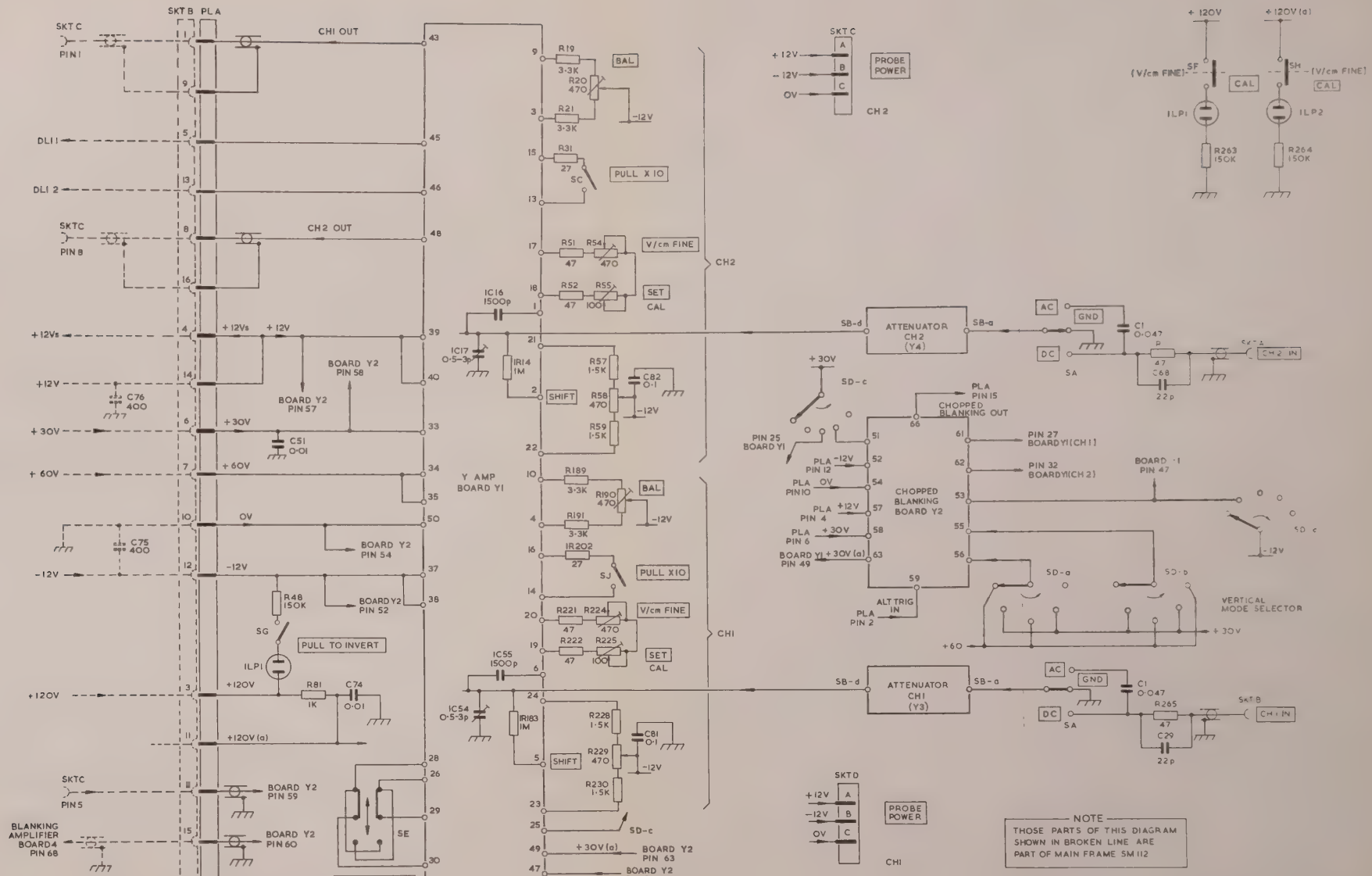


X-TIMEBASE MODULE SM602

BLOCK SCHEMATIC

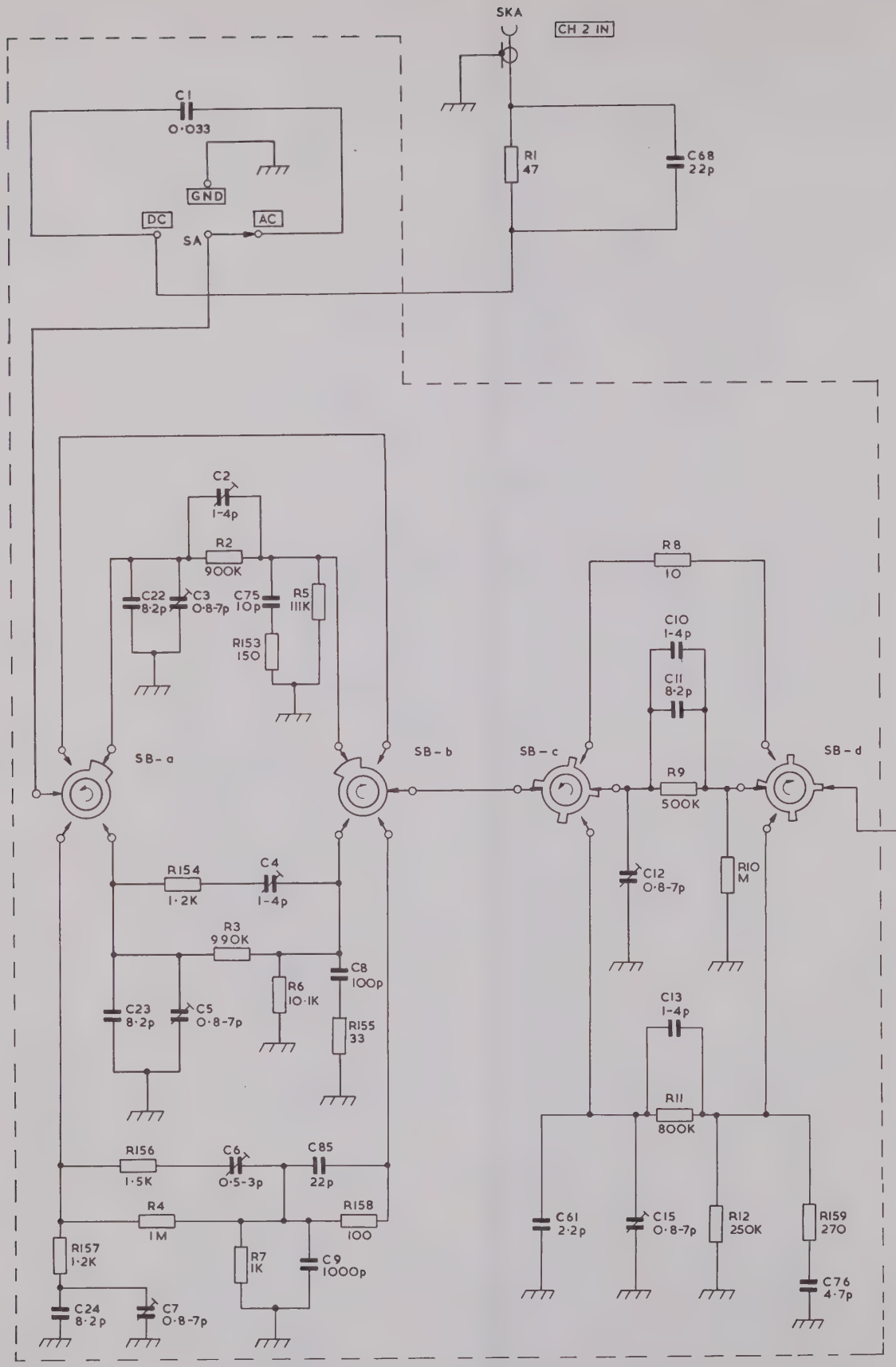

+5V
+60V
0V
-12V
+12V
+120V
SP
ILP2
R224 150K
A IN
SKA
C1 1p
R3 2·2M
R4 270K
R217 150
R216 150
SA-a
'F' 'G'
SM 602 (Sht.2)
SA
SB
1 CH. 1
2 CH. 2
3 EXT
4 EXT ÷ 10
5 LINE
1 AC
2 HF REJECT
3 LF REJECT
4 DC
SB-a
SB-b
C3 0·01
R206 100K
C2 100p
R7 47
R6 220K
R5 2·2M
R4 100p
R2 100K
C5 470p
IC6 1000p
IC8 0·1
IR9 1K
IR12 220
IR11 47
IC7 0·1
IC43 10
ITR1 2N5245
ITR2 TIS84
IR207 47
IR208 100
ITR7 40237
ITR8 40237
IR10 3·3K
IR13 1K
IR17 1·5K
IR18 47
IC9 0·1
ID7 IN4148
ID8 IN4148
ID9 3·3V
ID10 3·3V
IR24 3·3K
IR23 3·3K
IR25 47
IR27 15K
IR26 390
IC10 0·01
IR28 10K
IR29 1K
R30 10K
LEVEL
LEVEL CENTRE
C22 0·22
C20 16
SE-c
PULL FOR AUTO
SE-a
SE-b
SE-d
SE-e
C24 0·047
C25 430p
C27 47
IR213 10K
IR54 1K
IR59 100
IR58 10K
IR57 6·8K
ITR15 TIS48
ITR16 TIS48
IC18 0·01
R56 33K
IR53 1K
IR55 1K
IC19 220p
IC42 3300p
ID11 IN4148
IN7
IN1
ID14 5·1V
ID15 IN4148
ITR18 TIS48
IR62 2·2K
IR99 10K
IR98 3·9K
IR100 220
IR23 1000p
IR 204 2·2K
IR61 820
IR221 100
IC24 22p
IR63 2·4M
IR64 1·2M
IR65 480K
IR66 240K
IR67 120K
IR68 48K
IR69 24K
IR230
R70 12K
IR231
IR74 10
IC29 0·1
ITR20 TIS54
ITR19 2N5246
IR72 47K
IR71 47K
IC28 0·1
IC30 10
IR75 5K
+60V
ITR22 BCY72
R76 22K
R77 22K
R78 22K
R79 22K
IC31 0·1
IR80 27K
ITR21 BCI48
TIME/CM VAR
IR81 15K
ID13 6·2V
R82 1K
SET CAL
IR84 1K
R83 4·7K
IR201 180
IR202 1·5K
IR203 1K
IR205 1·5K
ITR25 BCY72
A SWEEP ZERO
IR85 47
IR86 220
ID17 IN 4148
ID16 IN 4148
ITR23 TIS48
'A' SWEEP LENGTH
IR87 39C
IR89 6·8K
IR88 2·2K
IR90 1K
IC32 33p
R91 4·7K
C82 0·0
IR94 1·8K
IR96 4·7
C33 16
H.F. SYNC
C34 25
R92 4·7K
R93 5K
C4 0·22
C35 0·027
C36 2200p
C38 470p
IC39 220p
ITR24 TIS48
IR95 100
IR97 1K
IC37 470p
IR107 270
IR73 4·7K
IR52 2·2K
IR39 150
IC13 220p
IR38 1·2K
IR36 560
IR42 470
IC16 1000p
ITR13 TIS54
'A' TRIG LEVEL
IR43 2·7K
IR44 1K
IR45 470
IR223 47
IR148 680
IR146 220
IR218 150
ID38 5·1V
IC81 0·1
IR150 2·2K
IR147 1K
IR149 1K
IC75 10
IN3
IR153 330K
IR151 2·2K
IR152 2·7K
DELAY
SM 602 (Sht.2)
SD
SLOPE
SM
IT1
BN
GN
R
W
BU
P
ID1 IN4148
ID2 IN4148
ID3 IN4148
ID4 IN4148
ID5 IN4148
ID6 IN4148
IC11 0·1
IC12 0·1
IC77 0·01
IC78 0·01
ITR6 40237
ITR9 40237
ITR10 40237
ITR11 40237
IR31 150
IR32 10
IR33 150
IR34 330
IR35 2·2K
IR37 47
IR228 680
NOTES
1 BROKEN LINES DENOTE CHASSIS MOUNTED ITEMS
2 PREFIX NUMBERS ON COMPONENT REFERENCES DENOTE PC BOARD Nos
3 INTEGRATED CIRCUIT PACKAGES N1 TO N6 SHOWN ON SHT 2
4 DWG No E.60597
X-TIMEBASE MODULE SM 602
CIRCUIT DIAGRAM (SHT.1) A SWEEP


NOTES
1. BROKEN LINES DENOTE CHASSIS MOUNTED ITEMS
2. PREFIX NUMBERS ON COMPONENT REFERENCES DENOTE PC BOARD NUMBER
3. DWG. No. E60597
N1, N2, N4, N5. SN 7400N (VIEWED ON TOP)
N3 SN 7271ON (VIEWED ON TOP)
N6 SN 7401N (VIEWED ON TOP)
N7 SN 7410N (VIEWED ON TOP)
SL
1 CH1
2 CH2
3 EXT
4 EXT ÷ 10
5 LINE
SF
1 AC
2 HF REJECT
3 LF REJECT
4 DC
SINGLE SHOT
RESET
PULL FOR GATED
SLOPE
LEVEL CENTRE
LEVEL
'B' SWEEP ZERO
'B' SWEEP LENGTH
'B' TRIG LEVEL
SH-a
SH-b
SH-c
SH-d
SJ-a
SJ-b
SJ-c
X-TIMEBASE MODULE SM602
CIRCUIT DIAGRAM (SHT 2) - B SWEEP



Y-AMPLIFIER MODULE SM 599

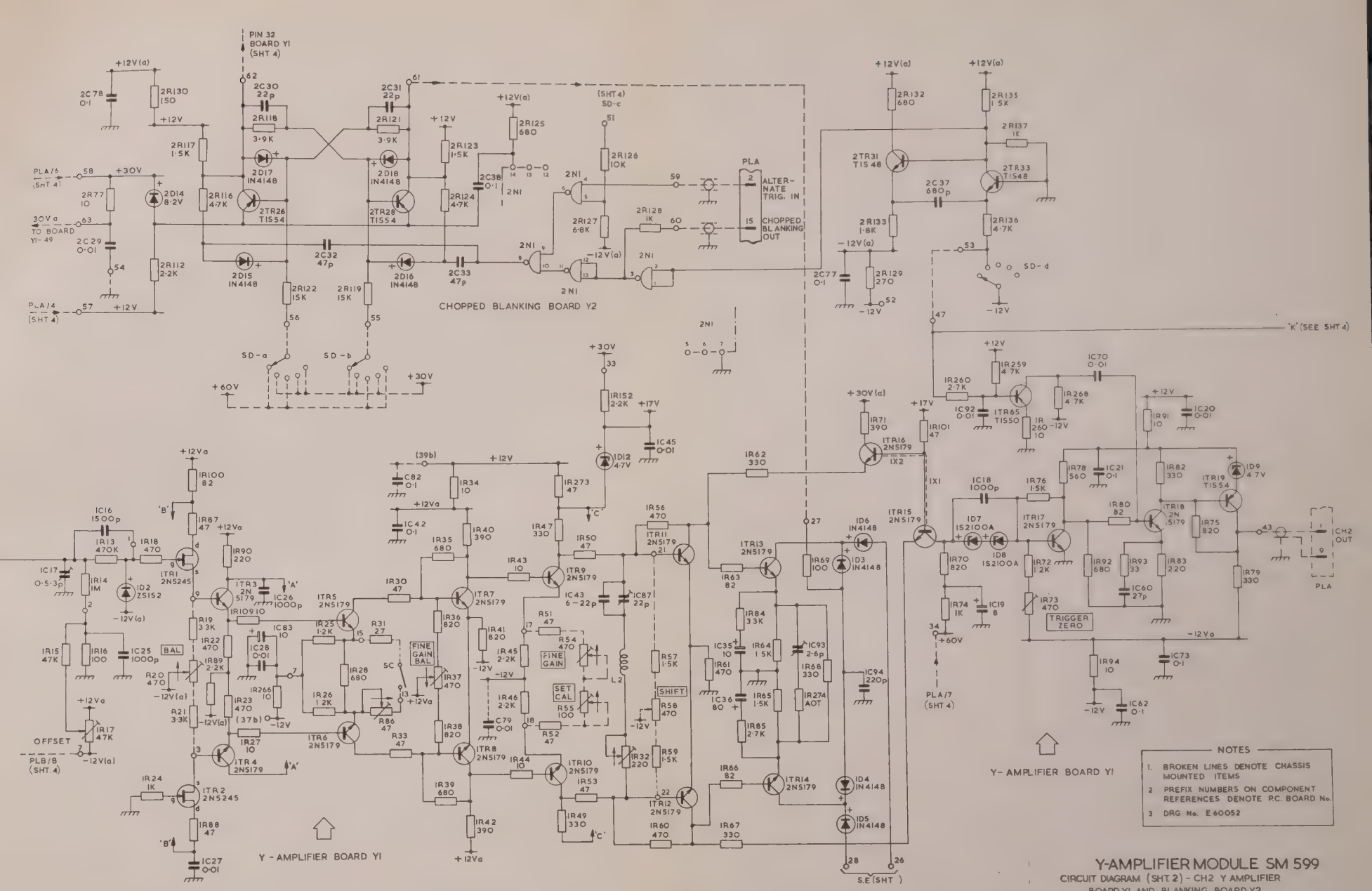
BLOCK SCHEMATIC



Y-AMPLIFIER MODULE SM599

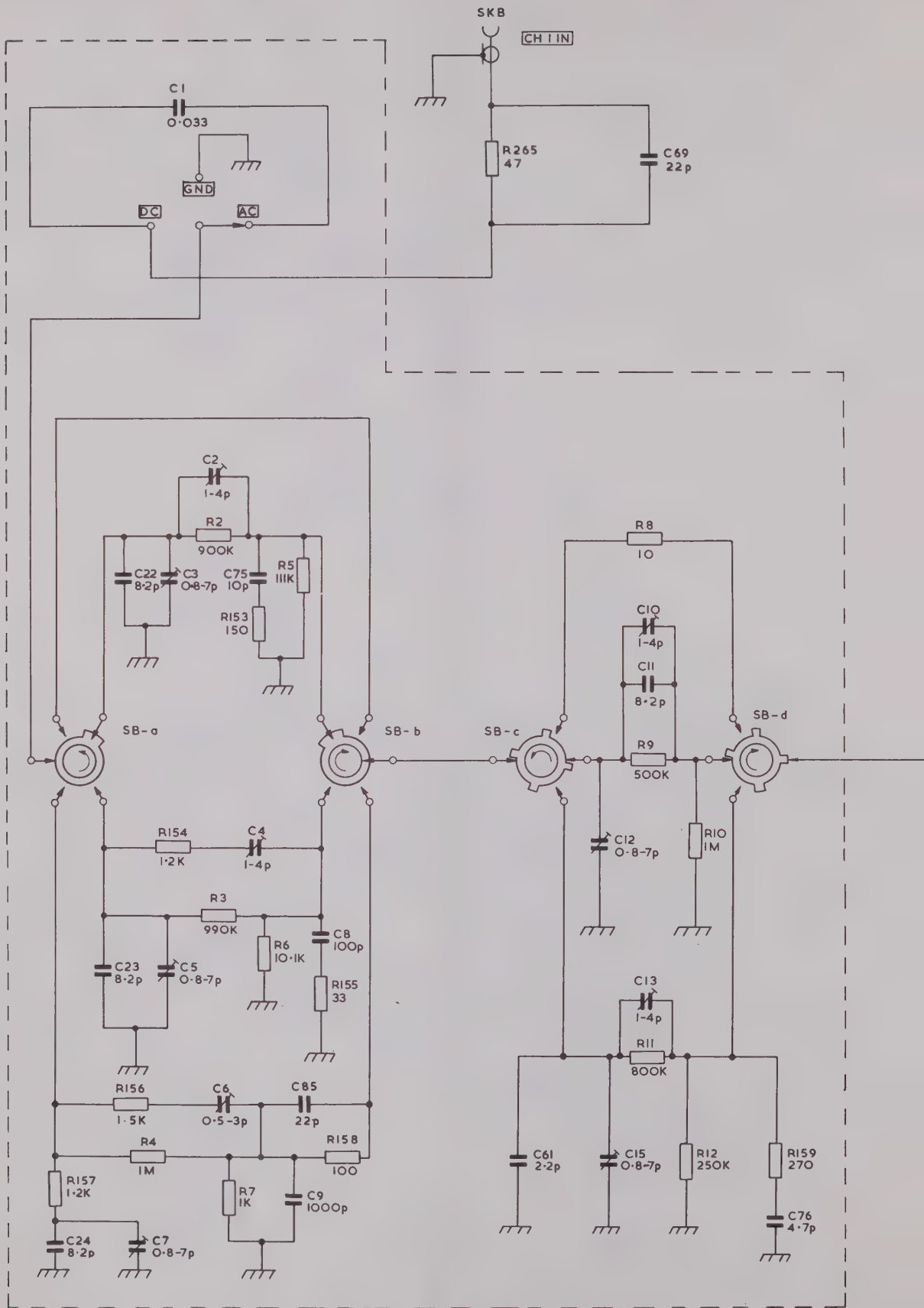
CIRCUIT DIAGRAM (SHT 1)

CH2 ATTENUATOR UNIT Y4



Y-AMPLIFIER MODULE SM 599

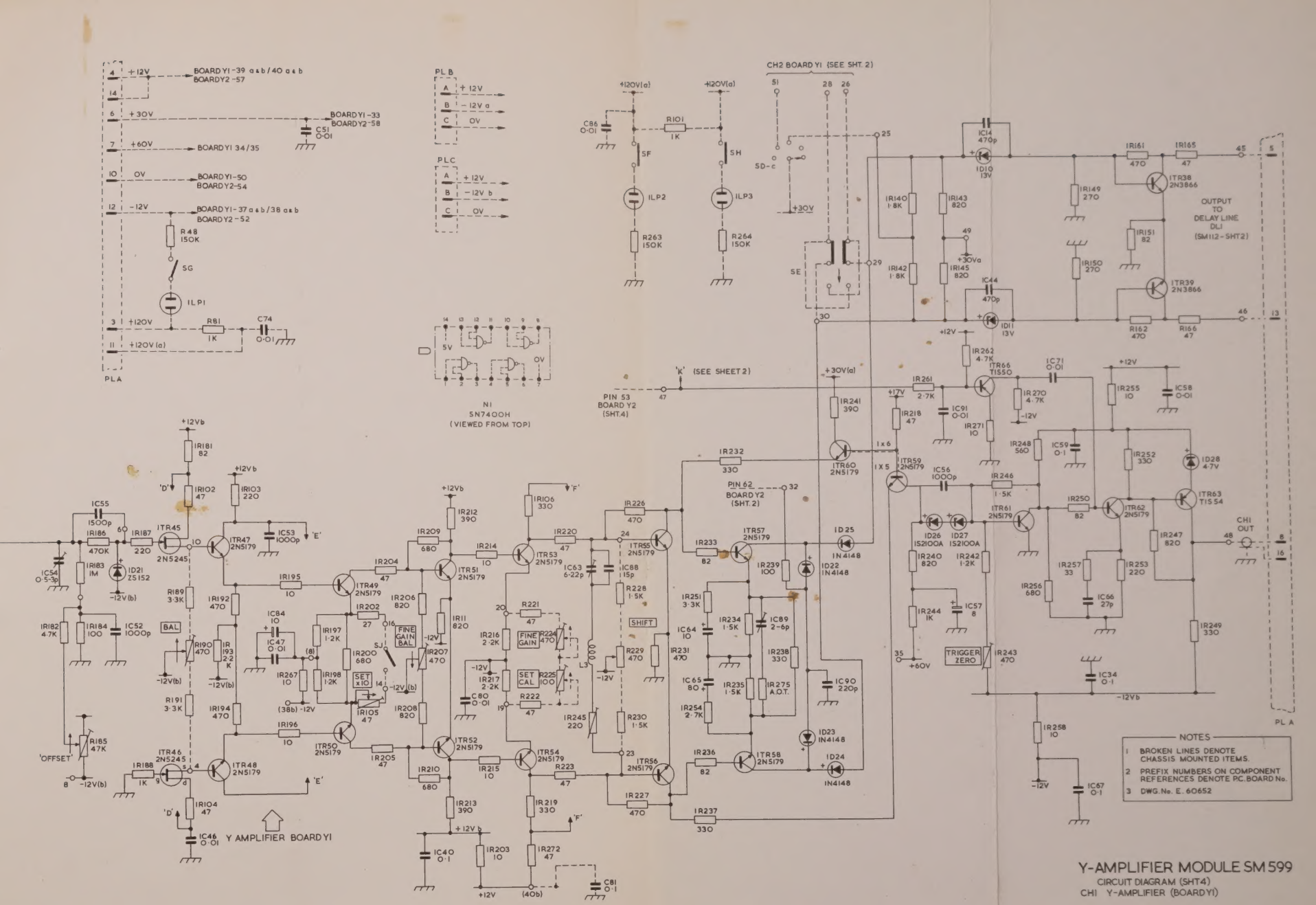
CIRCUIT DIAGRAM (SHT 2) - CH2 Y AMPLIFIER BOARD Y1 AND BLANKING BOARD Y2



Y-AMPLIFIER MODULE SM 599

CIRCUIT DIAGRAM (SHT 3)

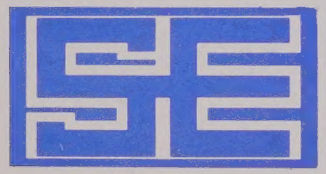
CHI ATTENUATOR UNIT Y3



Y-AMPLIFIER MODULE SM 599

CIRCUIT DIAGRAM (SHT4)

CH1 Y-AMPLIFIER (BOARD Y1)



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